GENERAL MOTORS CORPORATION

SLRV CONTROL STUDY
FINAL REPORT

Prepared for
Jet Propulsion Laboratories
Pasadena, California
Contract No. 951056

GM DEFENSE RESEARCH LABORATORIES

SANTA BARBARA, CALIFORNIA

LAND OPERATIONS DEPARTMENT

TR65-20

MARCH 1965

GENERAL MOTORS CORPORATION

SLRV CONTROL STUDY
FINAL REPORT

Prepared for
Jet Propulsion Laboratories
Pasadena, California
Contract No. 951056

This work was performed for the Jet Propulsion Laboratory, California Institute of Technology, sponsored by the National Aeronautics and Space Administration under Contract NAS7-100.

GM DEFENSE RESEARCH LABORATORIES

SANTA BARBARA, CALIFORNIA

LAND OPERATIONS DEPARTMENT

TR65-20

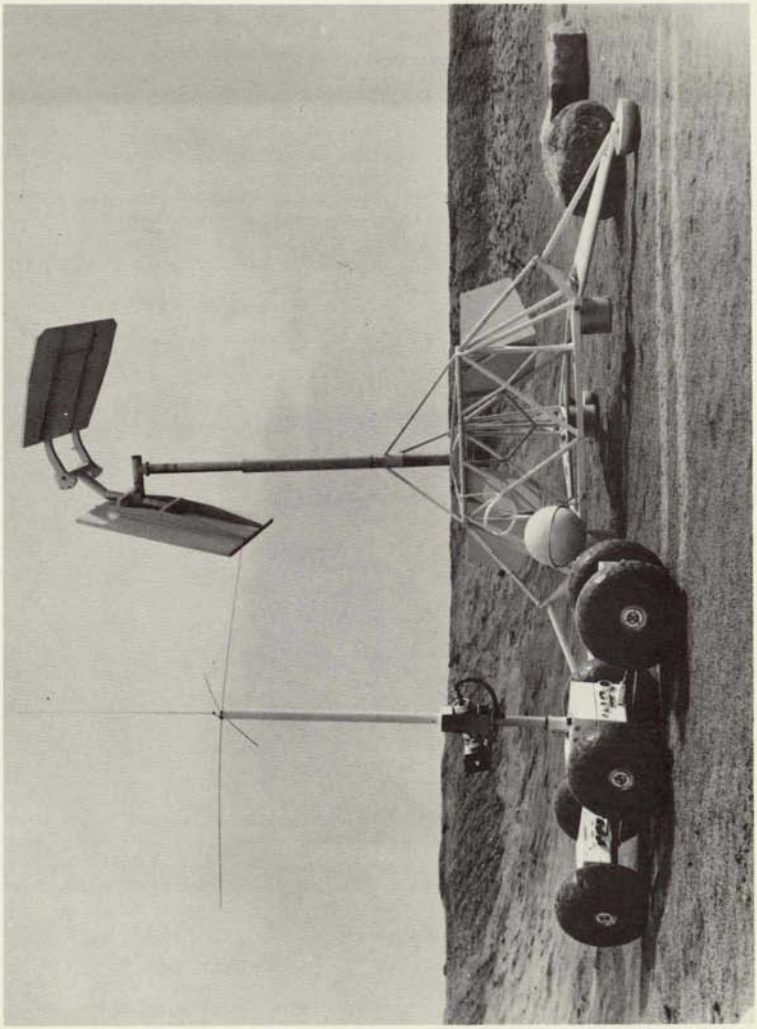
MARCH 1965

TABLE OF CONTENTS

ILLUSTRATIONS

ILLUSTRATIONS (Cont)

TABLES



INTRODUCTION

The SLRV Control Study was conducted to further investigate parameters which affect earth-based control of the Surveyor Lunar Roving Vehicle. This was accomplished at GM DRL through a three-phase evaluation-test program. This division into design studies, perception tests, and vehicle tests formed a natural approach to the problem, as it enabled fairly complete analysis of the control considerations as they relate to the SLRV mission and to the vehicle design points; evaluation of the perception problems and operator capabilities when viewing a television stereo image; and evaluation of the actual vehicle control problems associated with remote maneuvering of a vehicle by televised information.

SECTION I

DESIGN STUDIES

PROGRAM ASSUMPTIONS

Certain general assumptions had to be made in conducting the overall control study in order to provide continuity in the various efforts and a starting plateau for expanding or modifying the results. These assumptions were:

1. The basic vehicle, in terms of mobility and the command system, is essentially that defined at the end of SLRV Phase I. The major factors relating to the TV system are a means of presenting stereo TV images to the operators, either by a two-camera or a movable one-camera system, and a variable pitch capability in the vehicle camera(s).
2. The SLRV mission and mission plan are as stated at the end of SLRV Phase I.
3. Vehicle safety is of paramount importance.
4. All operations must be performed as rapidly as possible consistent with vehicle safety.

Where other assumptions were required for a particular activity, they are mentioned at that time.

VEHICLE SYSTEM PARAMETERS

The vehicle system parameters which relate to control, including the TV system characteristics, are discussed in Sections II and III of this report. The basic control features of these parameters are presented here as a summary to provide a grouping of the commentary. The basis for the comments appears in the other sections.

STEP-MOTION - A step-motion distance of 1/2-wheel revolution was used during the vehicle tests. A step distance of this magnitude appears to be proper for maintaining control in the large majority of cases. A capability for a standard 1/4-wheel revolution step, in addition to the 1/2-wheel revolution step, would be desirable for tight maneuvering or alignment of the vehicle with respect to an obstacle. The shorter step could be achieved by proper time sequencing of a STOP MOTION command. Steps greater than 1/2-wheel revolution will be infrequent unless traversing open ground where CONTINUOUS MOTION and STOP MOTION sequences would be used. With the ability to control a step length when necessary by a stop command, step-motion does not hinder control.

STEP-STEERING - The ETM steering angles of 0° (center), ± 7-1/2°, ±15°, ±22-1/2°, and ±30° were sufficient for most control problems. One-half step (3-3/4°) capability would have been useful at certain times, but using a pair of steering angles with partial motion steps accomplished the same result.

CAMERA LOCATION - A camera located on the center compartment offers some advantages for the vehicle controller over an end-compartment location. The primary advantages of driver orientation, greater field of view, including total area and stereo overlap directly in front of the vehicle, and more simple perceptive aids can be compensated for by operator training, past picture displays, and somewhat more complex ground equipment. Thus, for these aspects, the control features of camera location are considered other facets and not governing requirements in the trade-off with weight distribution, stowage, heat loads, etc. One aspect of vehicle control which may place a firm requirement on camera location is the need to be able to drive the vehicle forward or backward with equally effective safe mobility. This may well be achievable for either a center- or end-compartment camera location depending upon the vehicle silhouette and the use of previous pictures and command sequences (for backing the vehicle out of a dead-end situation).

CAMERA HEIGHT - The camera height of 35" with a 15° down angle corresponding to a front compartment height of 28" used during the control tests provided a very suitable operator's view of the terrain. Since the controller is interested in the ground features out to three or four vehicle steps, the effects of masking caused by a relatively low camera height are not particularly noticeable. For purposes of navigation and mapping, however, a

greater camera height would be desirable (neglecting factors of resolution and field angle) for viewing further away from the vehicle. By maneuvering the vehicle to elevated vantage points, additional effective camera height is achieved and a good survey of the terrain can be made. This action would be standard SLRV procedure.

FIELD OF VIEW - The selection of a horizontal field angle for SLRV will be the result of trade-offs based upon the mission objectives, the lunar terrain characteristics, and the TV system non-linearity magnitude and form as well as being based upon control requirements. Field of view is a complicated parameter to select because it affects things such as distortion, detectability, measurement accuracy, terrain evaluation(gradations), and photographic procedures. From an operator's standpoint, a field angle which encompasses the terrain three vehicle steps away for any steering angle is desirable. However, a narrower field of view can be used, as during the control tests, if sufficient overlap is provided in the TV pan system and the time necessary to take multiple pictures and pan the camera is available. Based upon the Phase I definition and small resultant TV system nonlinearities, particularly small local ones, the 45° horizontal field angle proposed in the Phase I report still appears valid.

STEREO BASELINE - Baseline has a direct effect on the accuracy of measurements in a stereo model. The wider the baseline, the more accurate the measurement. For vehicle control, the measurement accuracy feature becomes less important than for mapping, for example, because the operator is interested in subjects close to the vehicle. More important to control is the subject of stereo overlap which ties back to camera location and field angle. The selection of a baseline also depends upon the number of cameras, the complexity of mechanisms for a one-camera system, and the mission objectives. For the objectives used during Phase I with a two-camera system, a baseline as high as 20-24" may be desirable.

DETECTABILITY - Many parameters of the TV system and the characteristics of the lunar surface contribute to detectability. The perception tests showed that once an object was detectable it could be measured to a certain accuracy which changed very little as the subject became more detectable. Thus, the effects of parameters such as number of scan lines, complexity, and contrast depend mainly upon the characteristics of the terrain being viewed. During

EXPERIMENT CONTROL

- FUNCTION – LONG TERM NAV. & COMPLETION OF MISSION
- SCOPE – ENTIRE LANDING SITE AREA
- CONTROL TASK – DEFINE IO

PATH PLANNER

- FUNCTION – SHORT TERM NAV.
- SCOPE – 50 METERS AROUND VEHICLE
- CONTROL TASK – GUIDE SLRV TO IO BY DEFINING SERIES OF SROS

VEHICLE CONTROLLER

- FUNCTION – VECTOR SLRV
- SCOPE – 1 TO 6 METERS AROUND VEHICLE
- CONTROL TASK – SELECT COMMANDS TO VEHICLE

MOBILITY CHECKOUT

- FUNCTION – VEHICLE SAFETY
- SCOPE – NEXT COMMAND(S)
- CONTROL TASK – VALIDATE SELECTED COMMANDS FOR VEHICLE MOBILITY

Figure 1-1. Basic SLRV Control Functions

control will also be responsible for ensuring that the television data and soil measurement data necessary for site certification and mapping are obtained.

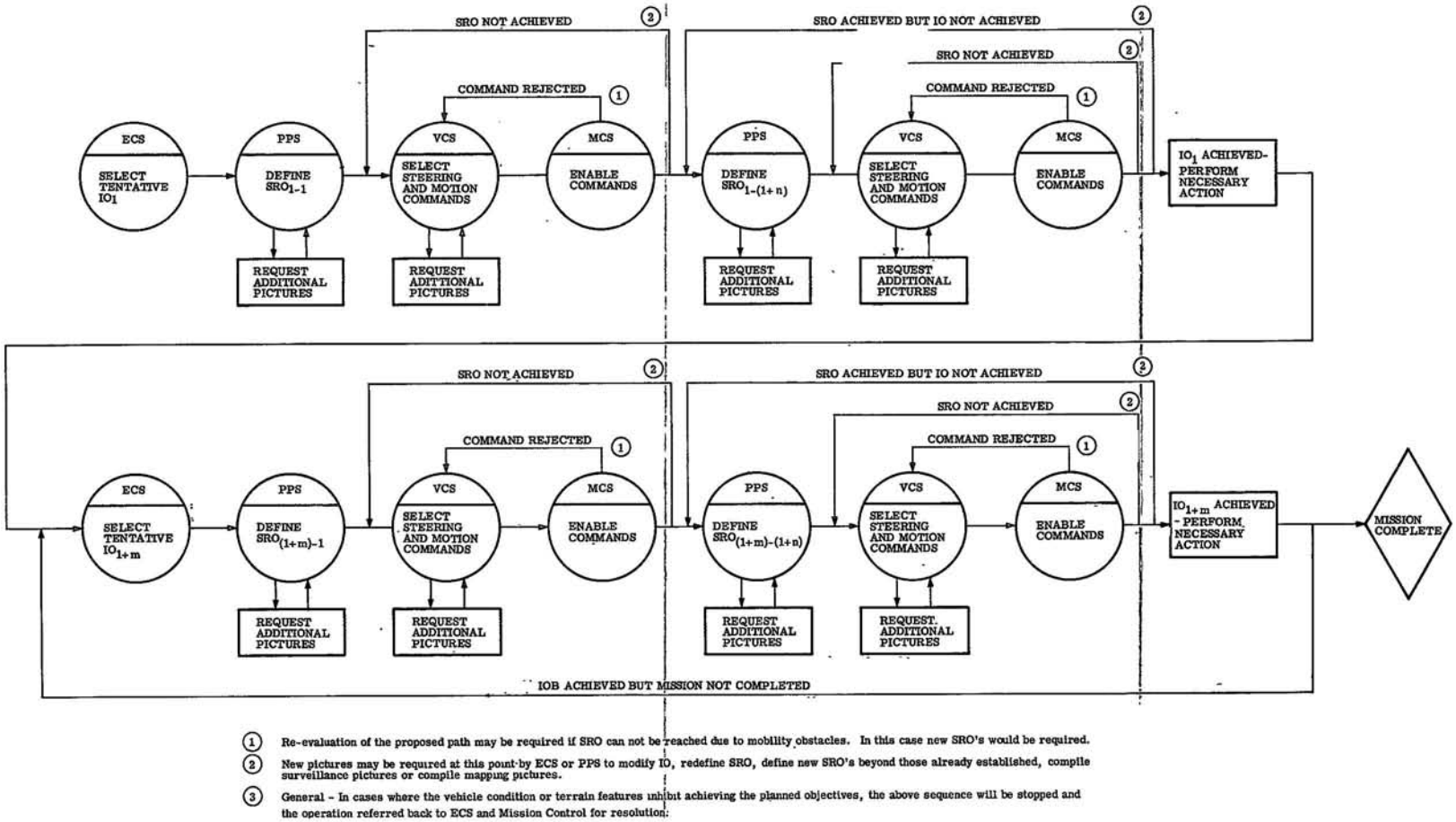
PATH PLANNER - The path planner section (PPS) will operate in a reduced domain extending from the vehicle to the next one or two IO's. The primary function of the PPS will be to direct the vehicle from one IO to the next IO over the best known route. This function of short-range navigation will be accomplished by establishing a series of short-range objectives (SRO's) which, when followed, will guide the vehicle to the next IO, by-passing major mobility obstacles and hazardous terrain. The SRO's will normally be spaced at 5 to 10 meter intervals with connecting routes which can be traversed in a straight line or slight arc. The SRO's will be provided to the vehicle controller in sequence as specific points to which the vehicle is to be vectored. While the vehicle is enroute from one SRO to the next, the PPS will request TV coverage of selected areas to acquire data necessary to plan ahead and establish a backlog of SRO's. By working ahead of the vehicle, the proposed sequence of SRO's can be refined to provide the most efficient route and reduce vehicle off time.

VEHICLE CONTROLLER - The responsibility of the vehicle controller section (VCS) will be to vector the roving vehicle from one SRO to the next. The SRO, along with the distance and azimuth angle from the vehicle to the SRO, will be provided to the VCS by the path planning section. With this approach, the vehicle controller can devote his full efforts to maneuvering the vehicle over terrain he can see well and is instinctively drawn to without concern for what is not immediately ahead of the vehicle. This should yield not only high efficiency but also high effectivity in issuing commands.

MOBILITY CHECKOUT - As a cross-check on the controller, the data presented to the VCS will also be provided to a mobility checkout section (MCS), or validator, along with the controller's maneuvering intention (steering angles and steps). The validator will have a series of measurement aids for use in evaluating terrain features in terms of vehicle mobility characteristics. The MCS will check such things as slope angles, clearance heights, step obstacle heights and crevice widths. Based upon these measurements and the controller's intended approach, the validator will enable or reject the intended commands. This function becomes almost automatic during the traversal of favorable terrain.

The general mode of operation of the control loop is shown in Figure 1-2. Experimental control defines the location of the first IO and provides this objective to PPS. The path planner then, from initial up- and down-look pictures, defines the first SRO. The location of the SRO in terms of range (full vehicle steps) and bearing (degrees right or left of the vehicle center compartment) is given to the controller. The VCS, in conjunction with the mobility checkout section, utilizes down-look pictures to determine motion and steering commands. Range and bearing to the SRO is updated based upon vehicle vectoring, and the controller will drive until the range and bearing become zero. While the vehicle is being driven to the first SRO, the PPS will utilize the down-look and requested up-look pictures to update the present SRO, if necessary, and to select SRO's further down the path. Similarly, experiment control will utilize the developing picture library and special request pictures to finalize or modify the IO location. The procedure of defining and vectoring to SRO's will continue until the IO is reached. The particular action required at the IO (search, certify, etc.) will be accomplished as necessary, the next tentative IO defined, and the procedure repeated until the mission is completed.

Considering the path planner, vehicle controller, and mobility checkout loop, the sequence of events involved in achieving an SRO would follow a routine similar to that shown in Figure 1-3. Assuming that the vehicle is at an SRO, the path planner requests three adjacent up-look pictures to verify the location of the next SRO, and from these pictures he provides the vehicle controller with a distance and heading to the next SRO. The location of the SRO will be marked possibly in one of the up-look pictures permanently available to the controller for orientation. Using his up-look picture, the controller identifies a reasonable path to the SRO which carries him left of the rock obstacles in the foreground, right down the corridor behind the rocks and then left to the objective. The controller will then command the camera into the down-look position and begin maneuvering the vehicle along the path based on his perceptive aids. The mobility checkout system will monitor the commands as a cross-check for mobility safety which, in this case, is basically to ensure obstacle avoidance. As each step is contemplated (will be) and executed (is now), the distance and azimuth angles to the SRO will be adjusted. At any point along the route to the SRO, pictures other than those shown for the



(1) Re-evaluation of the proposed path may be required if SRO can not be reached due to mobility obstacles. In this case new SRO's would be required.

(2) New pictures may be required at this pount by ECS or PPS to modify IO, redefine SRO, define new SRO's beyond those already established, compile surveillance pictures or compile mapping pictures.

(3) General - In cases where the vehicle condition or terrain features inhibit achieving the planned objectives, the above sequence will be stopped and the operation referred back to ECS and Mission Control for resolution.

Figure 1-2. SLRV Control Loop Operation

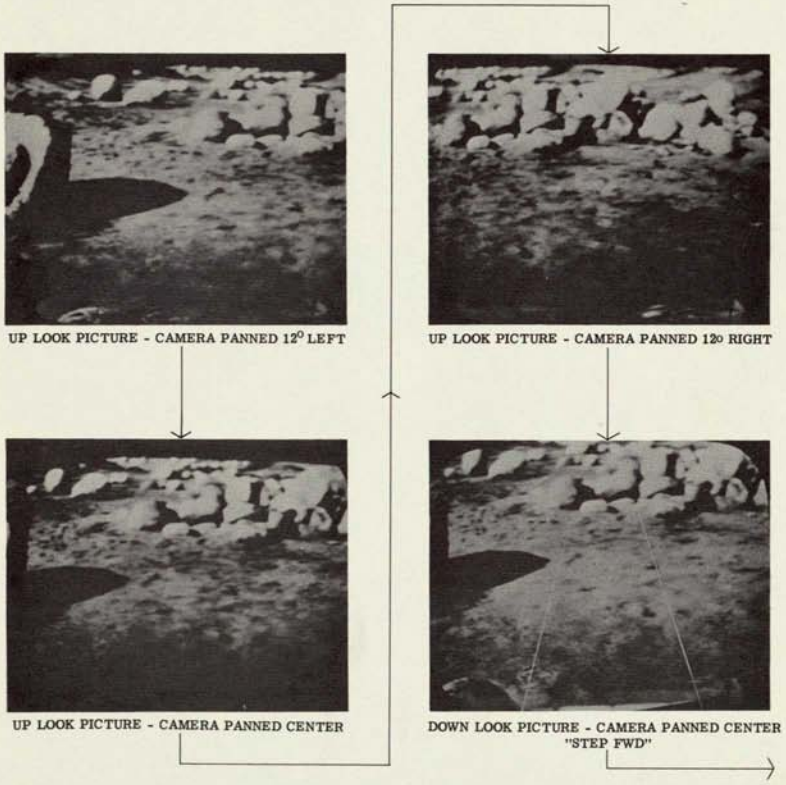


Figure 1-3. Picture and Command Sequence (Sheet 1 of 7)

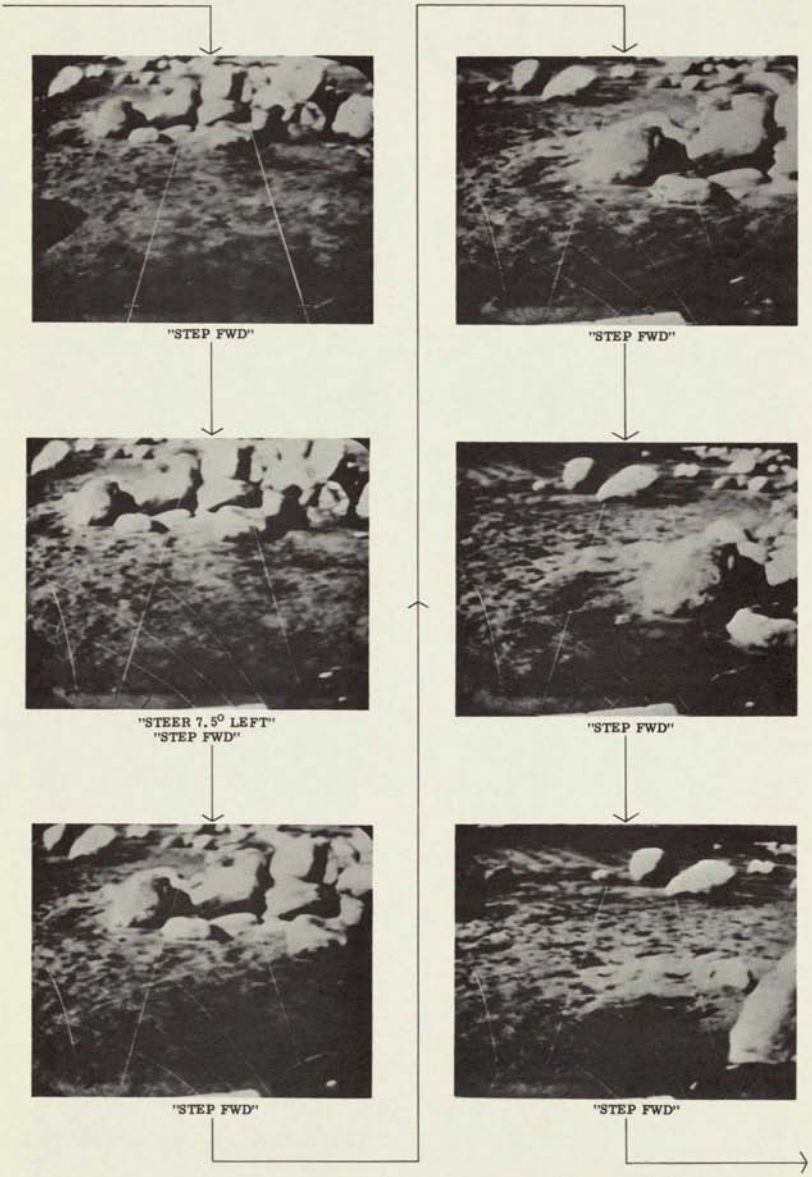
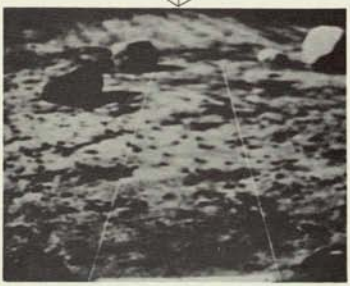


Figure 1-3. Picture and Command Sequence (Sheet 2 of 7)

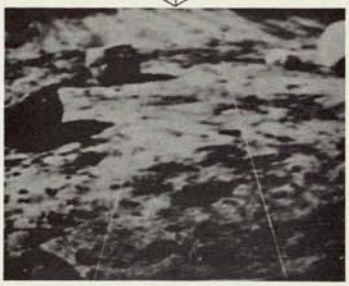
"ENTER PAN"
"PAN 12° RIGHT"
"PAN 12°RIGHT"

"PAN CENTER"
"ENTER STEER"
"CENTER STEER"
"STEP FWD"



"STEP FWD"

"STEP FWD"



"ENTER PAN"
"PAN 12° RIGHT"
"PAN 12° RIGHT"
"PAN 22° RIGHT"

"PAN CENTER"
"ENTER STEER"
"STEER 30° RIGHT"

Figure 1-3. Picture and Command Sequence (Sheet 3 of 7)

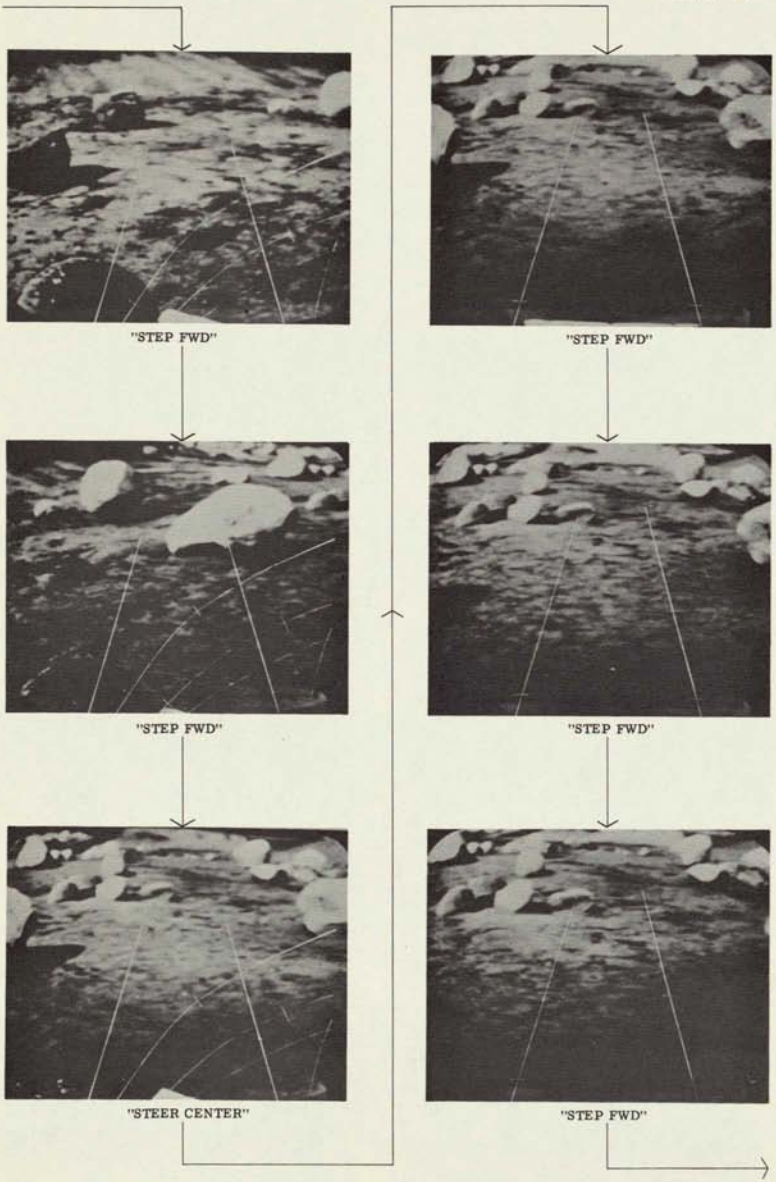


Figure 1-3. Picture and Command Sequence (Sheet 4 of 7)

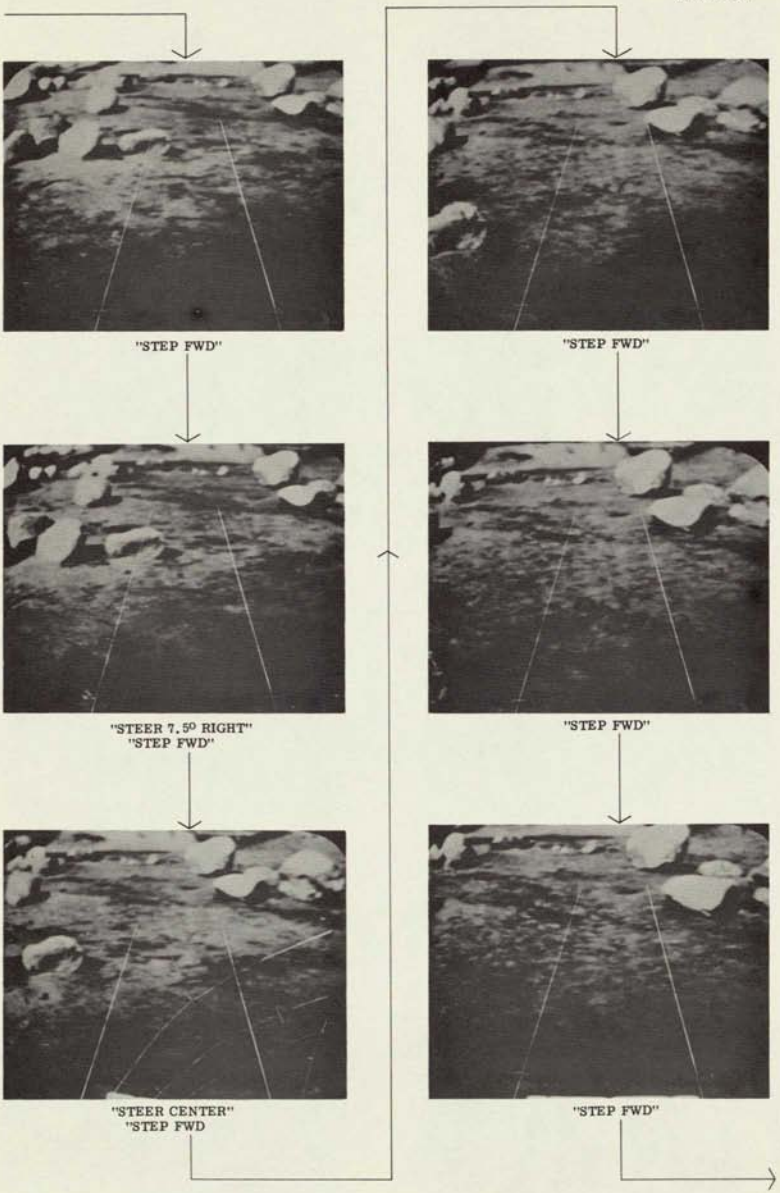
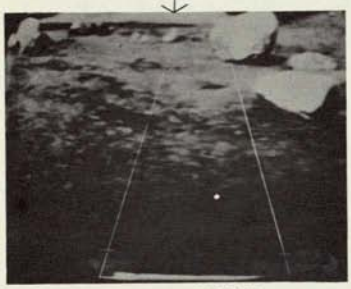
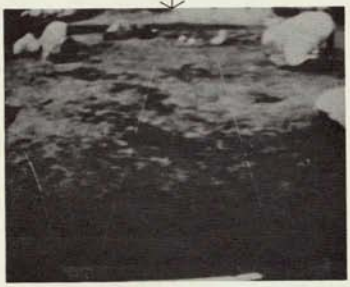


Figure 1-3. Picture and Command Sequence (Sheet 5 of 7)



"STEER 7.5° LEFT"
"STEP FWD"

"STEP FWD"



"STEP FWD"

"STEER CENTER"
"STEP FWD"

"STEP FWD"

"STEP FWD"

Figure 1-3. Picture and Command Sequence (Sheet 6 of 7)

"STEER 7.5° LEFT"
"STEP FWD"

"STEP FWD"

"STEER CENTER"
"STEP FWD"

Figure 1-3. Picture and Command Sequence (Sheet 7 of 7)

controller may be requested by PPS or ECS for purposes of acquiring data for mapping, refining or changing the IO location, or for refining or changing the SRO location. The sequence shown in Figure 1-3 covering 29 vehicle steps would have taken approximately 5 minutes to achieve during the control tests.

SECTION II

PERCEPTION TESTS

GENERAL

Objectives of the perception tests were to:

- Determine the accuracy with which an operator can establish size and range of simple three-dimensional subjects as photographed with television, by detecting and measuring the televised stereo models.
- Study the effects of variations in system and simple subject parameters upon operator performance.
- Establish the extent to which operator performance for a complex natural subject agrees with, and can be predicted by, combinations of his performance for simple subjects.
- Estimate the SLRV operator perception margin based upon the objectives listed above.

In general, system parameters may be separated into those which affect detection and identification of lunar terrain features, and those which affect measurement accuracy of such features.

Parameters which primarily affect detection and identification, for control purposes, are:

- Contrast
- Signal to noise ratio
- Resolution
- Attitude of stereo base relative to subject
- Surface complexity
- Masking of background features by foreground features

Once a feature becomes detectable, for example, as contrast exceeds the detection threshold, measurement accuracy is not appreciably increased with greater contrast.

The nature of the surface may be such that there are no homologous points. In this case, triangulation or stereo viewing would not permit determination of terrain slopes. Light gradations may be present due to the lunar photometric function, the angle of illumination, and the angle of viewing. These are not fusable as a stereo model permitting depth discrimination. However, one may record the changes in illumination knowing the photometric function and angles involved, and determine the slope.

Parameters which primarily affect measurement accuracy, for control purposes, are:

- Length of stereo base
- Distance to subjects
- Height of camera above ground
- Camera field angle
- Television system linearity

There are two areas in which total measurement error accumulates. First, the geometrical transformation from subject to stereo model will have distortions which cannot be entirely compensated for. Second, errors in measuring the stereo model will occur due to operator perception errors and limitations in the measuring techniques. Sophisticated photogrammetric techniques used to minimize readout error probably cannot be used because of relatively small values of television distortion.

The perception tests were limited to subjects which were a maximum of ten feet from the television camera. Perception margins were estimated out to this range and the error components due to television system and operator readout were determined.

SUMMARY OF PERCEPTION MARGINS

For the television and display system used for the perception tests, the best perception margin is ± 2 inches range error for a crevice edge averaging 7-1/2 feet from the camera and ± 4 degrees slope error for a slope averaging 9 feet from the camera. These values are for:

- 9" horizontal stereo base
- 45° camera field angle
- 30" camera height
- 5-1/2% television scan linearity

For the SLRV system, a television scan linearity of 0.5% or better is expected. With other parameters the same as above, the estimated perception margin for SLRV is ± 1 inch range error for a crevice edge and ± 2 degrees slope error.

The perception margins are based on the assumption that three dimensional fiducial marks, in some form, are used in the vehicle television system.

PHOTOGRAPHY, PROCESSING, AND DISPLAY

This section describes the equipment used to produce and display stereo photographs of predefined objects, using a closed circuit TV system, photographic camera, and conventional stereo projector.

General

The specific photographic subjects and selected parametric variations are defined under PHOTOGRAPHIC SUBJECTS. In each view a three-dimensional metric of eight points was suspended in the vicinity of the subjects. This simulated three-dimensional fiducial marks in the SLRV system which could be used as "yardsticks" to remove degradation caused by television transmission, reproduction, display, and interpretation.

Figure 2-1 shows the photographic setup. At the left is a 525-line closed circuit television camera; 13mm or 25mm focal length lenses were used as required. The camera was mounted on a slide bar such that two successive pictures comprised a stereo pair with adjustable length of baseline. The slide bar was adjustable to provide different orientations of the baseline relative to the subject.

The metric is suspended over a subject plane, in this case.

The output of the television camera was displayed on the monitor at the right. The monitor was photographed with a 35mm camera for each of two positions of the slide bar for each change of parameters. The resulting two negatives were printed and mounted in a standard 35mm stereo mount.

A video noise generator was connected to a second video input jack on the monitor. This permitted addition of white noise to the monitor picture. Signal to noise ratio was measured with an oscilloscope.

Figure 2-2 is a schematic of the operator test equipment. The stereo slides were projected from the stereo projector at the left onto the stereo rear projection screen at center. The operator, wearing polaroid glasses, sat with the back of his head against the headrest at the right. He viewed the stereo model and either placed the lighted tip of the measuring instrument successively on metric or subject points or he estimated subject locations relative to the metric. When the measuring point was placed at stereo model points, the test conductor read and recorded X, Y and Z coordinates from scales on the table or on the telescoping measuring instrument. Figure 2-3 is a photograph of the actual equipment.

Point Metric

The metric was constructed as shown in Figure 2-4. The nominal dimensions shown were measured to ± 0.025" and the measurements recorded for data reduction purposes. Each of the eight points was identified in the metric on a side of the spheres which was kept facing away from the TV camera. The connecting rods were marked every six inches to enable the viewer to estimate measurements in terms of the point metric.

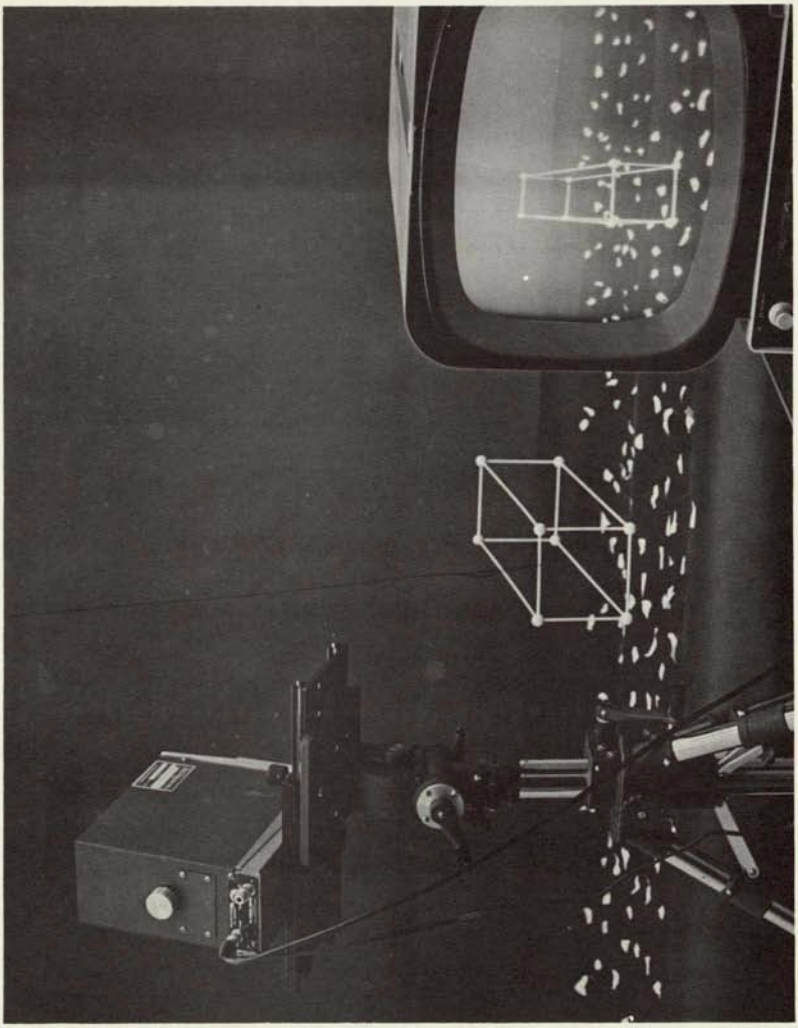


Figure 2-1. Television Photographic Setup

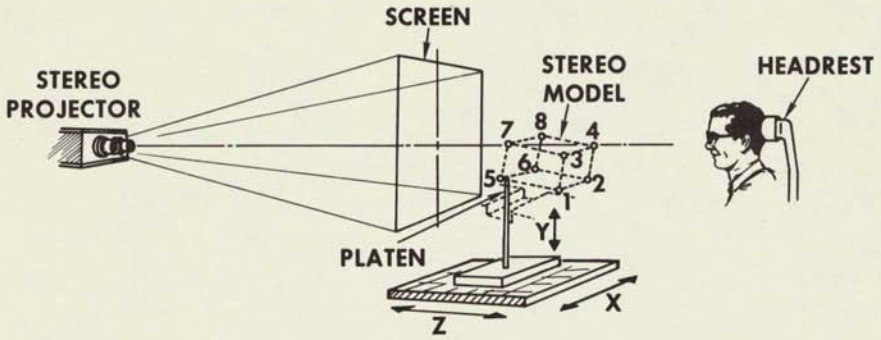


Figure 2-2. Operator Test Setup

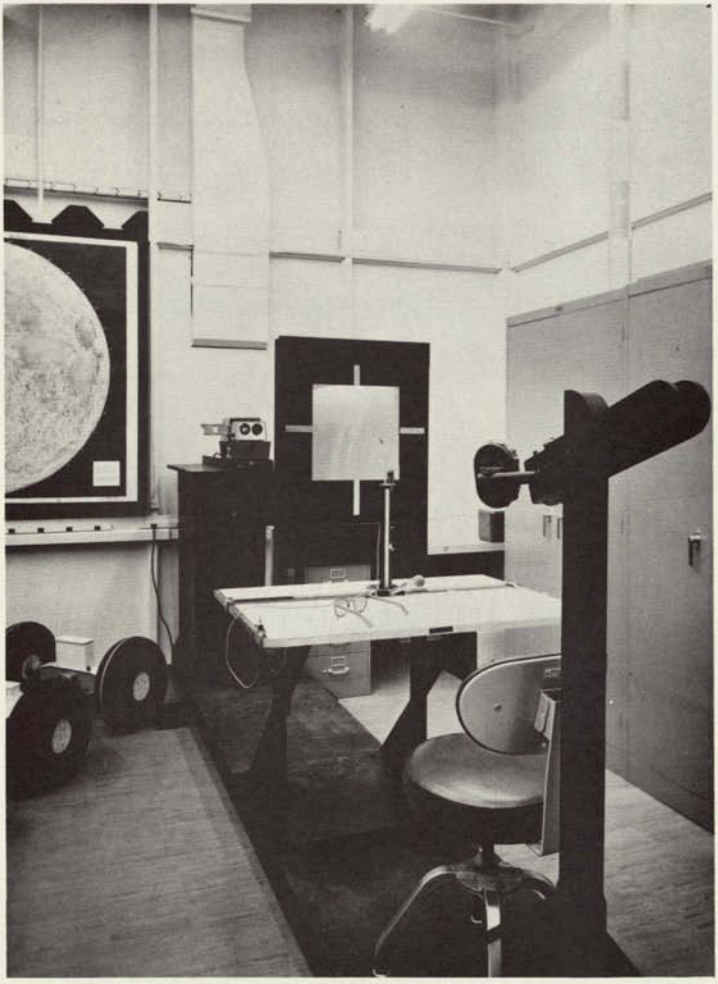


Figure 2-3. Operator Test Equipment

STRUCTURE WHITE WITH
6" BLACK ROD SEGMENTS

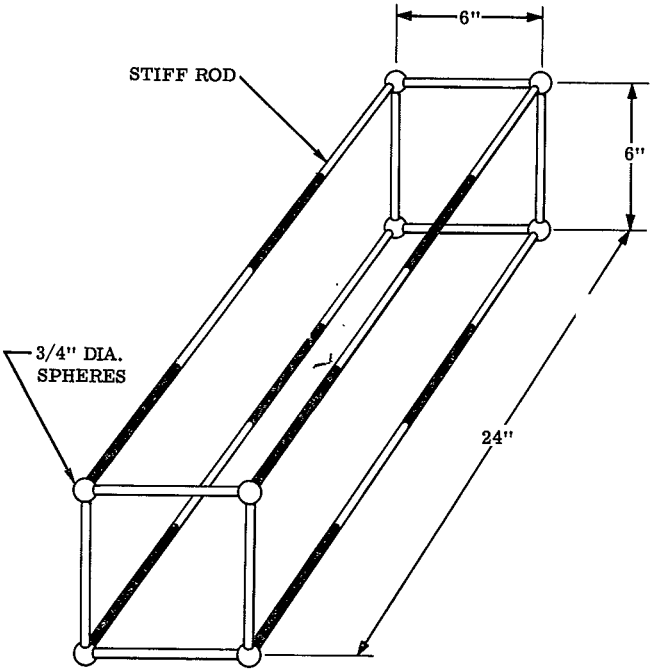


Figure 2-4. Metric Construction

Television Photography

The television camera was placed in an orthogonal coordinate frame of reference such that the left camera front nodal point was always at X = 0, Z = 0, and Y = h (Figure 2-5). All measurements were made with respect to this coordinate frame. Placement of the point metric is shown in Figure 2-6. The front bottom pair of points was in a plane parallel to the XZ plane and centered between the two optical axes. The television camera optical axis for the two camera positions was perpendicular to the baseline within 1^{o}, and parallel within 1^{o}. Measurements were made and recorded for each stereo pair as defined under PHOTOGRAPHIC SUBJECTS.

Monitor Photography

The photographic camera was placed in front of the television monitor as shown in Figure 2-7. Two different distances from camera to screen were used.

With a 13mm lens on the TV camera, the distance (D) from photographic camera to screen was adjusted so that height of the TV image just filled the height of the photographic frame. Negatives with 525 horizontal scan lines were produced.

With a 25mm lens on the TV camera, an object appeared twice as large on the screen as with the 13mm lens. Doubling the photographic camera to screen distance caused the object to appear the same size on the photographic frame as with the 13mm TV lens. Effectively there were then 1050 scan lines over the frame height.

The photographic camera optical axis passed through the center of the screen within 1/4" and was perpendicular to the screen within 5^{o} The horizontal axis of the photographic camera aperture plate was parallel within 20' of arc to lines in the TV image which are parallel to the TV camera baseline. Such a line in the image was established by the path of a point in the TV camera field as the TV camera was moved along the slide bar. This requirement was to eliminate the necessity for rotation of frames when they were placed in a stereo mount.

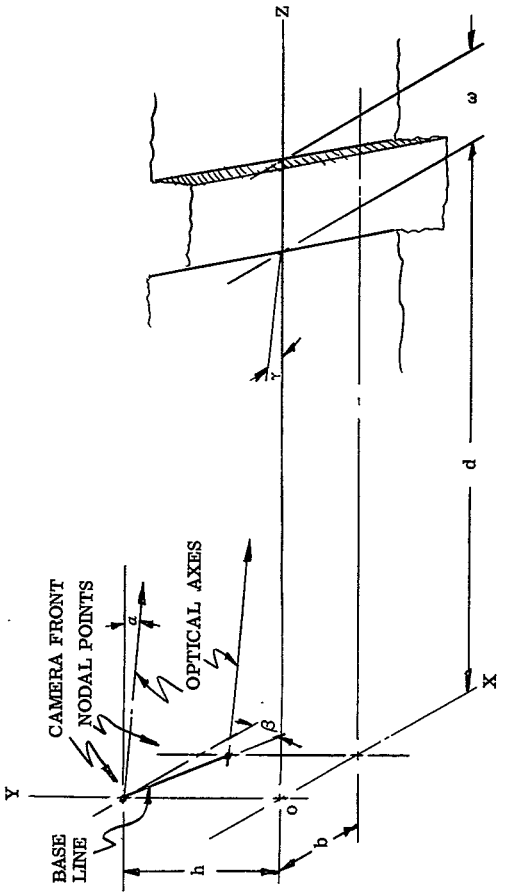


Figure 2-5. Photographic Geometry

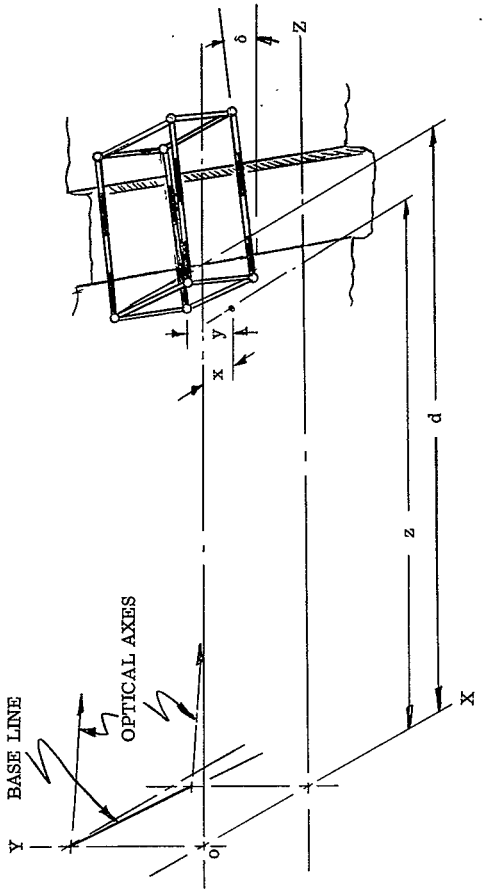
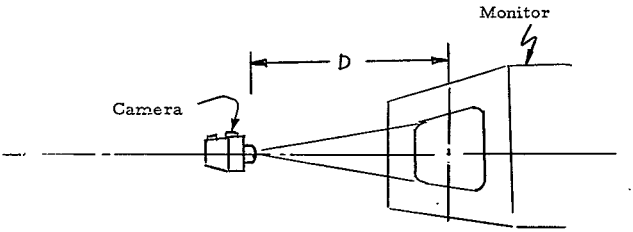
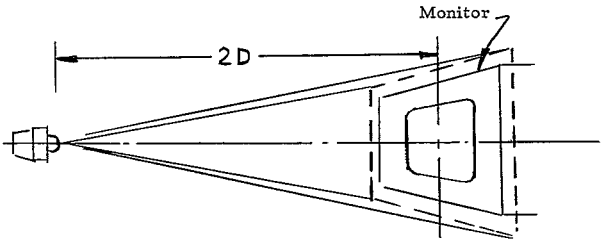


Figure 2-6. Metric Geometry



Set-up for 525 Active Scan Lines



Set-up for 1050 Active Scan Lines

Figure 2-7. Monitor Photography

At the start of each roll of film, a stereo pair was made including a standard grey scale in the field being photographed. The lightest and darkest values were measured at the monitor screen and recorded.

Development and Printing

Standard film development procedures was used for the negatives. Film prints were made so as to maintain a 1/1 scale ratio as nearly as possible. The contrast of the prints were to be varied to control grey scale in accordance with the requirements delineated under PHOTOGRAPHIC SUBJECTS. This did not prove to be practical or necessary within the scope of the perception tests.

Mounting of Stereo Transparencies

The stereo transparencies were mounted in standard 35mm glass stereo slides. Each slide contains a mask with two openings whose vertical edges were used as references for spacing of homologous points in the transparencies. The projector toe-in adjustment was used to superimpose the two mask openings on the screen. Homologous points which should lie in the plane of the screen were therefore mounted so that they were equidistant from corresponding mask edges. Homologous points which did not lie in the plane of the screen, in the stereo model, were mounted so that they were at different calculated distances from corresponding mask edges. Tolerance in horizontal mounting did not exceed $\pm$ 0.010" (for a tolerance at the screen of $\pm$ 0.125"). Vertical deviation tolerances at the slide were held to $\pm$ 0.005".

PHOTOGRAPHIC SUBJECTS

General

A test matrix of 96 stereo slides was produced. Each slide portrayed a crevice and a slope permitting data reduction for depth perception of a line at two distances and measurement of a slope from each slide.

The test matrix proposed for the perception tests involving simple objects, was designed to:

(a) Simplify data reduction

(b) Maximize the amount of data obtainable from a limited number of test situations

(c) Permit selection of test situations for more intensive study

To meet objectives (b) and (c) it is desirable to evaluate the effect of each parameter in a variety of situations. However, the number of parameters is such that, even after severely limiting the number of values of each parameter to be tested, a test pattern utilizing all possible permutations of the test parameters is clearly impractical. The test matrix permits achievement of the test objectives without having to test all possible permutations.

Although the use of all permutations is impractical, the number of permutations of all parameters except the camera-obstacle attitude is reasonable (48). The test matrix runs through all of these permutations twice, giving a total of 96 stereo pairs; this permits the assignment of each attitude to six different combinations of the remaining parameters. The assignments are designed to maximize the number of pairs of stereo slides between which a single parameter is varied to permit easy identification of the effect of each parameter. The number of data points available for variation of each parameter is sufficient to permit reasonable confidence in the results. Also, each parameter is tested under a variety of combinations of the other parameters.

In addition to the data obtainable from single parameter variation pairs, the distribution of each parameter throughout the matrix assures a reasonable degree of randomness. The degree of randomness is sufficient to permit the use of statistical data reduction techniques within the usual limitations of small sample statistics. The distribution of parametric values also permits the identification of significant areas for further investigation within the limits imposed by the specification of values for each parameter.

After the slides were made it was discovered that the important additional parameter of television geometrical distortion was being changed with, for

instance, length of baseline. This effect was also studied in the analysis of matrix test results.

The actual matrix values used are listed for each of the 96 slides in Table 2.1. Four typical slides are numbers 12, 13, 14 and 15. One member of each stereo pair is shown in Figures 2-8, 2-9, 2-10 and 2-11.

Photographic Symbology

- h = Height of front nodal point of television camera lens when camera is in left eye position
- α = Pitch angle of TV camera lens where depression below horizontal is positive
- β = Roll angle of stereo baseline with respect to horizontal. β is positive when right eye picture is depressed below the left eye picture
- b = Length of baseline
- θ = Horizontal field angle when transparency is masked in stereo slide mount
- ϕ = Vertical field angle when transparency is masked in stereo slide mount
- F. L. T. = Focal length of TV camera lens
- A_T = Aperture setting of TV camera lens
- w = Width of crevice
- d = Distance to subject from front nodal point of left position of TV camera lens. Front edge of a crevice
- C = Subject complexity code
- G = Grey scale variation of subject
- x = Horizontal position parallel to baseline of metric point number one
- y = Vertical position of metric point number one
- z = Horizontal position perpendicular to plane containing baseline of metric point number one

TABLE 2-1.

PERCEPTION TEST PHOTOGRAPHIC DATA

Slide No.	TV Camera					Subject					Metric			
	h	β	γ	b	Lens	d	Slope	Comp	Grey Scale	S/N	δ	X	Y	Z
1	18	0	0	5	13	90	0	1	1	1	10	-0.5	2.6	85.0
2	18	0	0	5	13	90	0	1	1	2	10	-0.5	2.6	85.0
3	30	0	15	5	25	90	10	1	1	1	9	-1.0	4.4	86.3
4	18	0	30	5	13	90	10	1	2	1	17	0	1.9	85.0
5	30	90	0	5	13	90	0	2	1	1	10	-0.5	2.6	85.0
6	18	90	0	5	13	90	0	3	1	1	10	-0.5	2.6	85.0
7	18	0	15	9	13	90	10	1	1	1	9	-1.0	4.4	86.3
8	18	0	0	9	13	90	0	1	1	2	10	-0.5	2.6	85.0
9	30	45	0	9	25	90	0	1	1	1	10	-0.5	2.6	85.0
10	18	0	30	9	13	90	10	1	2	1	17	0	1.9	85.0
11	30	90	0	9	13	90	0	2	1	1	10	-0.5	2.6	85.0
12	18	0	15	9	13	90	10	3	1	1	9	-1.0	4.4	86.3
13	18	90	15	5	13	108	10	2	1	2	9	-1.0	4.4	104.3
14	18	45	0	5	25	108	0	2	1	1	10	-0.5	2.6	103.0
15	18	90	15	5	13	108	10	2	2	1	9	-1.0	4.4	104.3
16	18	90	0	5	13	90	0	3	1	2	10	-0.5	2.6	85.0
17	18	45	0	5	25	90	0	3	1	1	10	-0.5	2.6	85.0
18	18	45	30	5	13	108	10	3	2	1	17	0	1.9	103.0
19	30	0	0	5	13	90	0	1	2	2	10	-0.5	2.6	85.0
20	18	90	30	5	25	108	10	1	2	1	17	0	1.9	103.0

TABLE 2-1.

PERCEPTION TEST PHOTOGRAPHIC DATA (CONT)

Slide No.	TV Camera					Subject					Metric			
	h	β	γ	b	Lens	d	Slope	Comp	Grey Scale	S/N	δ	X	Y	Z
21	30	0	15	5	25	90	10	1	1	2	9	-1.0	4.4	86.3
22	18	0	0	9	13	90	0	2	1	2	10	-0.5	2.6	85.0
23	30	45	0	9	25	90	0	2	1	1	10	-0.5	2.6	85.0
24	18	0	30	9	13	90	10	2	2	1	17	0	1.9	85.0
25	18	0	15	9	13	90	10	3	1	2	9	-1.0	4.4	86.3
26	30	45	0	9	25	90	0	3	1	1	10	-0.5	2.6	85.0
27	18	45	0	9	13	108	0	3	2	1	10	-0.5	2.6	103.0
28	30	0	0	9	13	90	0	1	2	2	10	-0.5	2.6	85.0
29	30	90	0	9	25	90	0	1	2	1	10	-0.5	2.6	85.0
30	30	0	15	9	25	90	10	1	1	2	9	-1.0	4.4	86.3
31	18	90	15	5	13	108	10	2	2	2	9	-1.0	4.4	104.3
32	18	90	15	5	25	108	11.5	2	2	1	14	1.0	2.8	104.5
33	18	0	15	5	13	90	10	3	2	2	9	-1.0	4.4	86.3
34	18	45	0	5	25	108	0	3	2	1	10	-0.5	2.6	103.0
35	18	90	0	5	25	108	0	2	1	2	10	-0.5	2.6	103.0
36	18	90	0	5	25	90	0	3	1	2	10	-0.5	2.6	85.0
37	30	0	30	5	25	90	10	1	2	2	17	0	1.9	85.0
38	18	0	0	9	25	90	0	2	1	2	10	-0.5	2.6	85.0
39	30	90	0	9	25	90	0	2	2	1	10	-0.5	2.6	85.0
40	18	90	0	9	25	90	0	3	1	2	10	-0.5	2.6	85.0

TABLE 2-1.

PERCEPTION TEST PHOTOGRAPHIC DATA (CONT)

Slide No.	TV Camera					Subject					Metric			
	h	β	γ	b	Lens	d	Slope	Comp	Grey Scale	S/N	δ	X	Y	Z
41	18	45	0	9	25	108	0	3	2	1	10	-0.5	2.6	103.0
42	30	0	0	9	13	90	0	2	2	2	10	-0.5	2.6	85.0
43	18	0	15	9	13	90	10	3	2	2	9	-1.0	4.4	86.3
44	30	0	15	9	25	90	10	1	2	2	9	-1.0	4.4	86.3
45	18	45	15	5	25	90	10	2	2	2	9	-1.0	4.4	86.3
46	18	90	0	5	25	90	0	3	2	2	10	-0.5	2.6	85.0
47	18	0	0	9	25	90	0	2	2	2	10	-0.5	2.6	85.0
48	30	45	0	9	25	90	0	3	2	2	10	-0.5	2.6	85.0
49	18	0	15	5	13	90	11.5	1	1	1	14	1.0	2.8	86.5
50	30	0	0	5	13	90	0	1	1	2	10	-0.5	2.6	85.0
51	18	45	0	5	25	108	0	1	1	1	10	-0.5	2.6	103.0
52	30	0	30	5	13	90	10	1	2	1	17	0	1.9	85.0
53	18	45	15	5	13	108	10	2	1	1	9	-1.0	4.4	104.3
54	18	45	0	5	13	90	0	3	1	1	10	-0.5	2.6	85.0
55	18	0	30	9	13	90	10	1	1	1	17	0	1.9	85.0
56	30	0	0	9	13	90	0	1	1	2	10	-0.5	2.6	85.0
57	30	90	0	9	25	90	0	1	1	1	10	-0.5	2.6	85.0
58	18	90	30	9	13	108	10	1	2	1	17	0	1.9	103.0
59	18	45	15	9	13	108	10	2	1	1	9	-1.0	4.4	104.3
60	18	45	30	9	13	108	10	3	1	2	17	0	1.9	103.0

TABLE 2-1.

PERCEPTION TEST PHOTOGRAPHIC DATA (CONT)

Slide No.	TV Camera					Subject					Metric			
	h	β	γ	b	Lens	d	Slope	Comp	Grey Scale	S/N	δ	X	Y	Z
61	18	45	15	5	13	108	10	2	1	2	9	-1.0	4.4	104.3
62	30	0	15	5	25	90	10	2	1	1	9	-1.0	4.4	86.3
63	18	90	30	5	13	108	10	2	2	1	17	0	1.9	103.0
64	18	90	0	5	13	108	0	3	1	2	10	-0.5	2.6	103.0
65	18	45	0	5	25	108	0	3	1	1	10	-0.5	2.6	103.0
66	18	90	15	5	13	108	10	3	2	1	9	-1.0	4.4	104.3
67	30	0	30	5	13	90	10	1	2	2	17	0	1.9	85.0
68	18	45	30	5	25	108	10	1	2	1	17	0	1.9	103.0
69	18	90	0	5	25	108	0	1	1	2	10	-0.5	2.6	103.0
70	30	0	0	9	13	90	0	2	1	2	10	-0.5	2.6	85.0
71	30	90	0	9	25	90	0	2	1	1	10	-0.5	2.6	85.0
72	18	45	15	9	13	108	11.5	2	2	1	14	1.0	2.8	104.5
73	18	90	0	9	13	90	0	3	1	2	10	-0.5	2.6	85.0
74	18	45	0	9	25	90	0	3	1	1	10	-0.5	2.6	85.0
75	18	45	30	9	13	108	10	3	2	1	17	0	1.9	103.0
76	30	0	30	9	13	90	10	1	2	2	17	0	1.9	85.0
77	18	90	30	9	25	108	10	1	2	1	17	0	1.9	103.0
78	18	90	0	9	25	108	0	1	1	2	10	-0.5	2.6	103.0
79	18	45	15	5	13	108	10	2	2	2	9	-1.0	4.4	104.3
80	18	90	30	5	25	108	10	2	2	1	17	0	1.9	103.0

TABLE 2-1.

PERCEPTION TEST PHOTOGRAPHIC DATA (CONT)

Slide No.	TV Camera					Subject					Metric			
	h	β	γ	b	Lens	d	Slope	Comp	Grey Scale	S/N	δ	X	Y	Z
81	30	0	30	5	13	90	10	3	2	2	17	0	1.9	85.0
82	18	45	30	5	25	108	10	3	2	1	17	0	1.9	103.0
83	30	45	0	5	25	90	0	2	1	2	10	-0.5	2.6	85.0
84	18	90	0	5	25	108	0	3	1	2	10	-0.5	2.6	103.0
85	30	0	15	5	25	90	10	1	2	2	9	-1.0	4.4	86.3
86	30	45	0	9	25	90	0	2	1	2	10	-0.5	2.6	85.0
87	18	90	30	9	25	108	10	2	2	1	17	0	1.9	103.0
88	18	45	0	9	25	90	0	3	1	2	10	-0.5	2.6	85.0
89	18	45	0	9	25	90	0	3	2	1	10	-0.5	2.6	85.0
90	18	0	30	9	13	90	10	2	2	2	17	0	1.9	85.0
91	18	45	30	9	13	108	10	3	2	2	17	0	1.9	103.0
92	18	90	0	9	25	108	0	1	2	2	10	-0.5	2.6	103.0
93	18	90	15	5	25	90	10	2	2	2	9	-1.0	4.4	86.3
94	30	0	30	5	25	90	10	3	2	2	17	0	1.9	85.0
95	18	0	30	9	25	90	10	2	2	2	17	0	1.9	85.0
96	18	45	0	9	25	90	0	3	2	2	10	-0.5	2.6	85.0
97	18	0	30	9	-	108	10	3	2	-	17	0	1.9	103.0

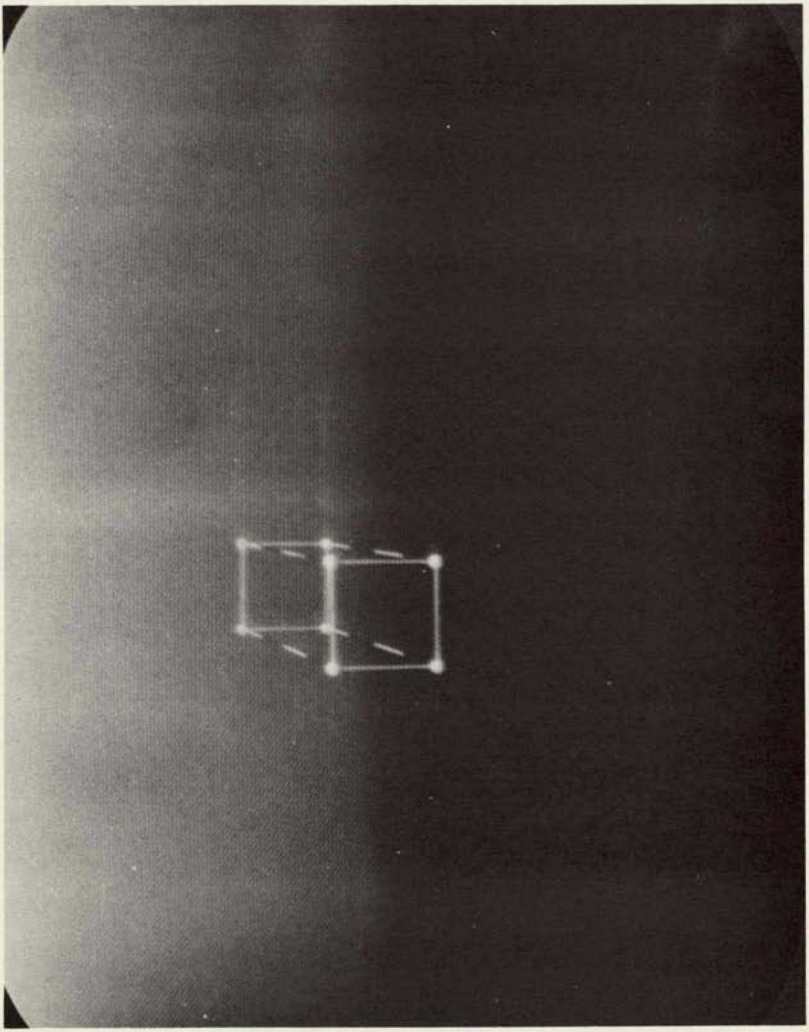


Figure 2-8. Typical Stereo Slide - #12

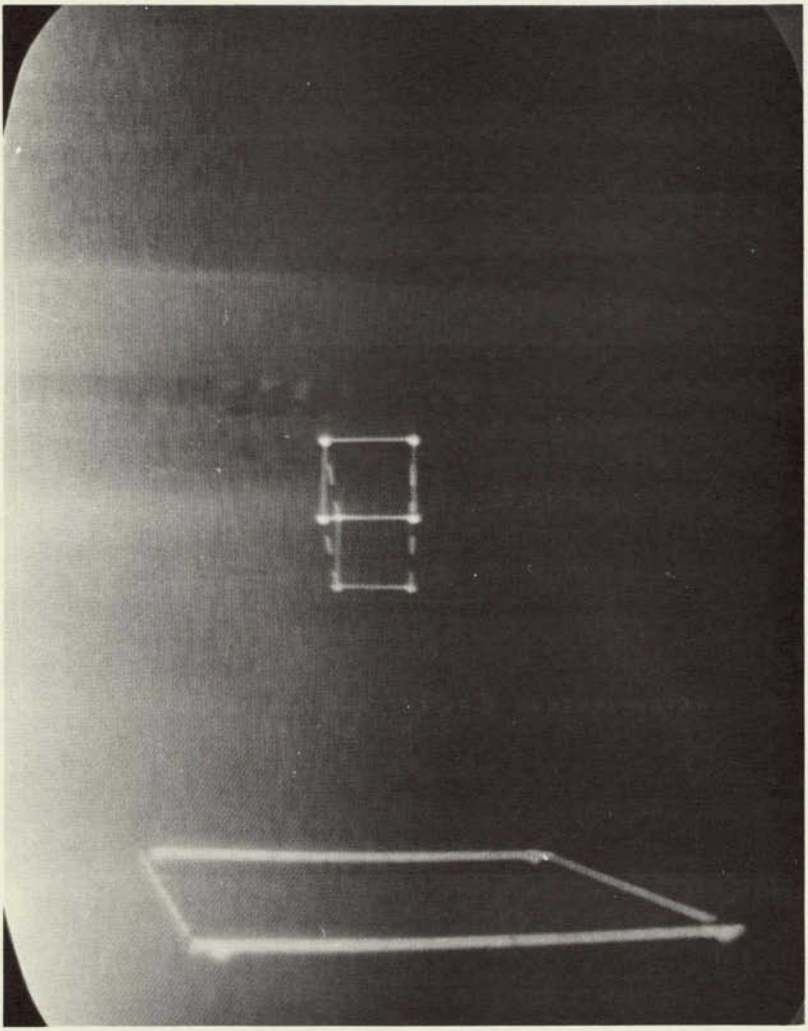


Figure 2-9. Typical Stereo Slide - #13

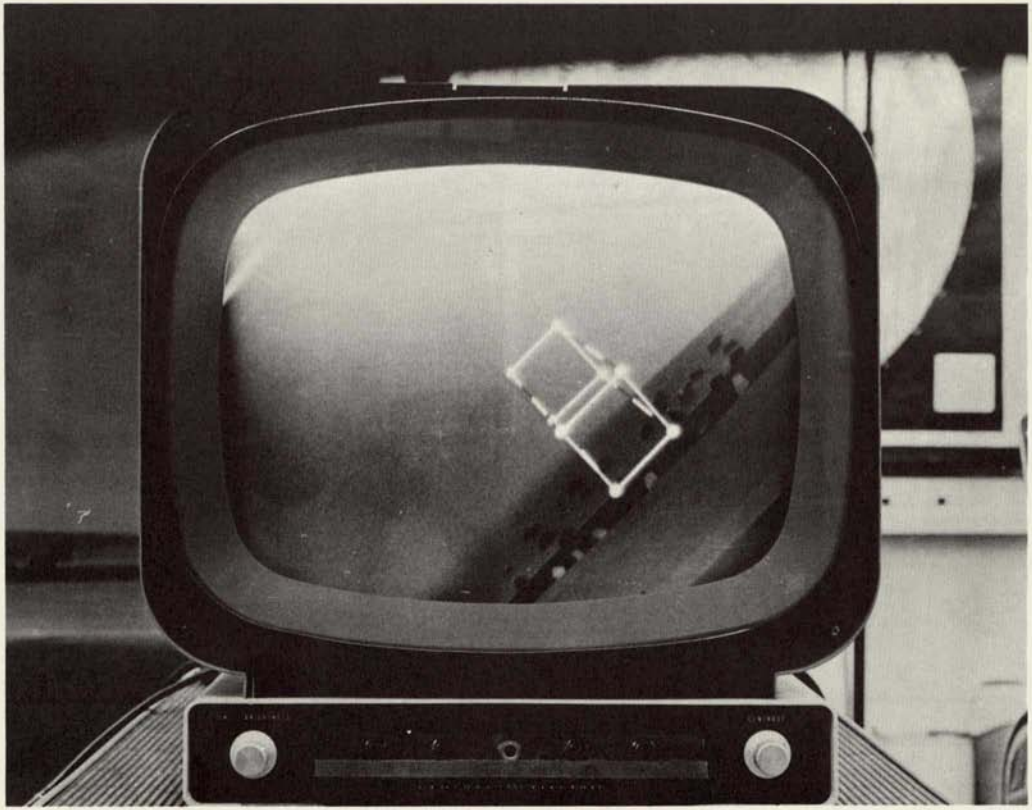


Figure 2-10. Typical Stereo Slide #14

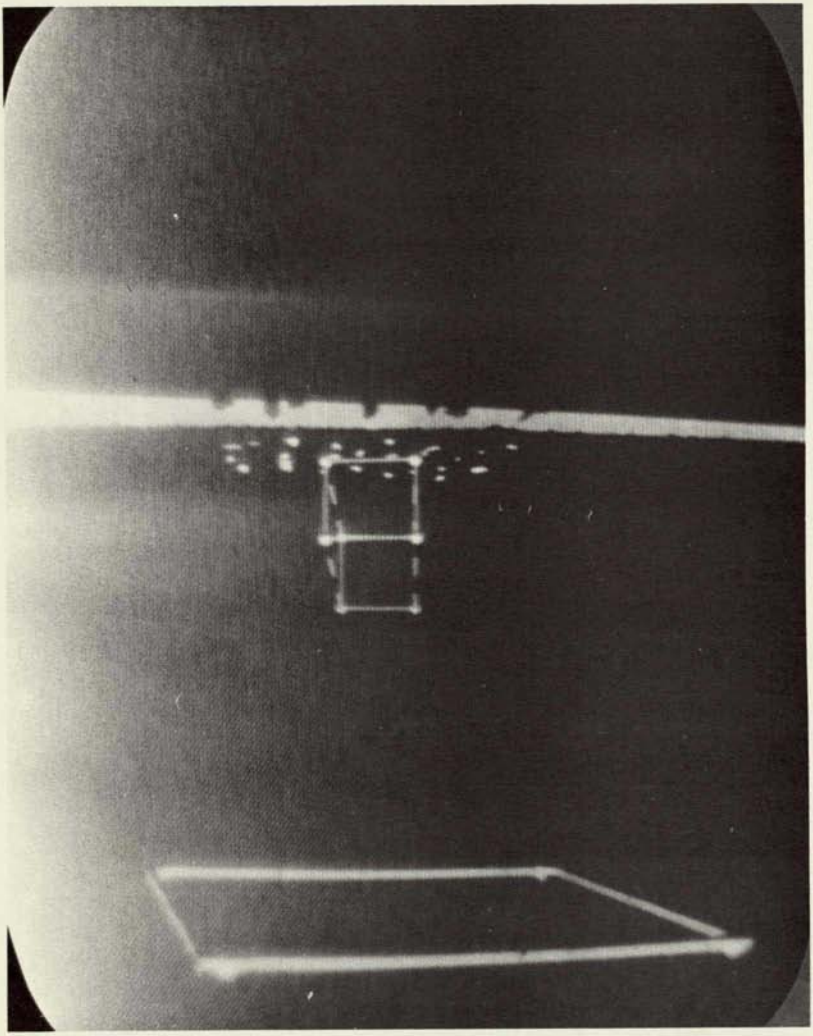


Figure 2-11. Typical Stereo Slide - #15

δ = Angle between xz plane and line through metric points 1 and 5

A_C = Aperture setting of photographic camera lens

D = Distance from TV monitor screen to front nodal point of photographic camera lens

γ = Yaw angle of vertical plane through stereo baseline relative to horizontal straight line subject

t = Exposure time

F = Film and ASA rating

F.L.C. = Focal length of photographic camera lens

S/N = Signal to noise ratio of one TV scan at the monitor times $\sqrt{30}$

C/R = Contrast ratio of image as measured at the monitor

Codes for Test Parameters

Baseline -

#1 - 5 inches

#2 - 9 inches

Complexity -

Line #1 - Smooth

#2 - Irregularities larger than resolution elements

#3 - Irregularities smaller than resolution elements

Slope #1 - Three points each larger than resolution elements

#2 - Many points each larger than resolution element

#3 - Many points each smaller than resolution element

Grey Scale -

#1 - Contrast ratio just larger than $\sqrt{2}$

#2 - Contrast ratio 10/1

Resolution -

#1 - 525 active TV lines

#2 - 1050 active TV lines

S/N -

#1 - 30 db

#2 - 10 db

Attitude -

α #1 - 11^{o} (h = 18")

#2 - 17^{o} (h = 30")

β #1 - 0^{o}

#2 - 45^{o}

#3 - 90^{o}

γ #1 - 0^{o}

#2 - 15^{o}

#3 - 30^{o}

Distance -

#1 - 90 inches

#2 - 108 inches

OPERATOR TESTING

The operator to be tested was seated in front of the rear projection stereo screen as shown in Figure 2-2. (Note: For reasons of eye comfort, he was requested to look away from the screen as the test conductor changed slides and checked alignment.)

For stereo model subjects lying in front of the screen, the operator moved the platen to coincide with the stereo model point to be located. The test conductor read and recorded the coordinates of the platen. Each time the platen was moved to a new subject it was first moved in random fashion to remove measurement bias.

For stereo model subjects located in back of the screen, the operator moved the platen until its reflection coincided with the stereo model to be located. The test conductor read and recorded the coordinates of the platen, making note that the model was behind the screen.

The operator, for each slide, found a comfortable head position. The same head position was held constant, as far as possible, between measurements for each slide.

Three operators were originally tested by a physician for normal depth perception. Two of the operators were used throughout the tests. The third operator, with excellent judgment and depth perception otherwise, was unable to make reliable measurements for a stereo image between him and the screen. With the screen about 30 inches from the operator's eyes, this merely meant that, like many people, he was unable to fuse an image with less than about a 10:1 subject distance to interpupillary distance ratio. When the stereo projector toe-in adjustment was made so stereo model objects in front of the screen were made to appear in back of the screen, the third operator had no trouble in measuring the image. Nevertheless, for the perception tests, it was attempted to maintain an approximately angle true stereo model and the third operator was replaced by a fourth operator who could view all stereo models without difficulty.

Of ten people, including three operators, who were associated with the control study, five were unable to measure points in the stereo model. In some cases this was due to interaction between scan structure in the television image and the individual's astigmatism. In at least two other cases, individuals had little or no normal depth perception. Obviously, operators must be carefully selected for such work.

There was no evidence of fatigue for test periods of about an hour per operator.

TEST DATA AND RESULTS

Operator Depth Discrimination For Well Defined Points

Total error in measurement of terrain features using a stereo television system is the sum of television system errors and operator readout errors. It is desirable, therefore, to determine operator error in locating points in the stereo model so that total error can be separated into television system and measurement error components. For this purpose, each of three operators measured the position of the eight metric points in each of twenty-five

slides. For each slide, the slide and projector adjustments were left unchanged between operator readings.

With the type of stereo display used, a difference in location of points as perceived by different observers will occur if their interpupillary distances are not the same. This is illustrated in Figure 2-12. Human interpupillary distances vary from about 55mm to 75mm. The three operators varied from 63mm to 70mm. Their readings clearly illustrated this effect. Therefore, all readings were normalized to values which would be measured by an operator with average (64mm -2-1/2") interpupillary distance. Readings were also normalized to account for slightly different eye-to-screen distances using the same headrest.

The standard deviations in range measurements, based on normalized data, were computed for 200 points for each of the three operators. Standard deviations for operators, A, B and C were 0.27", 0.23" and 0.22". Average standard deviation was 0.23". These values were averages for metric points whose position varied randomly from 20" to 40" from the operator's eyes in the stereo model. In the object space using a 5" baseline, the average standard deviation would be 0.46" for points from 40" to 80" from the camera. Using a 9" baseline the average standard deviation would be 0.83" for points from 72" to 144" from the camera.

Figure 2-13 shows boundary curves of maximum readout errors for operator C who had the smallest standard deviation. Also shown are curves of maximum operator error which were calculated, assuming depth perception corresponding to eye resolution of one minute of arc. These values are equaled or bettered in human depth perception measurements. The difference between the two sets of curves can be attributed to the quality of the television image, the television stereo model, and the measurement tools.

By careful consideration of these factors, it will be possible to reduce operator readout error to more nearly correspond with theoretical limits.

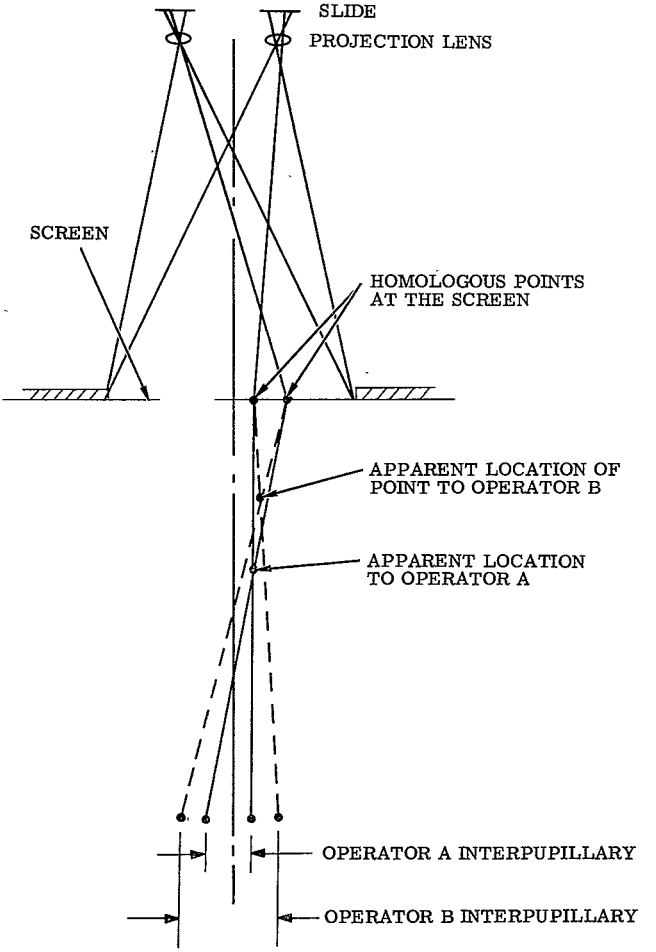


Figure 2-12. Effect of Interpolating Variations

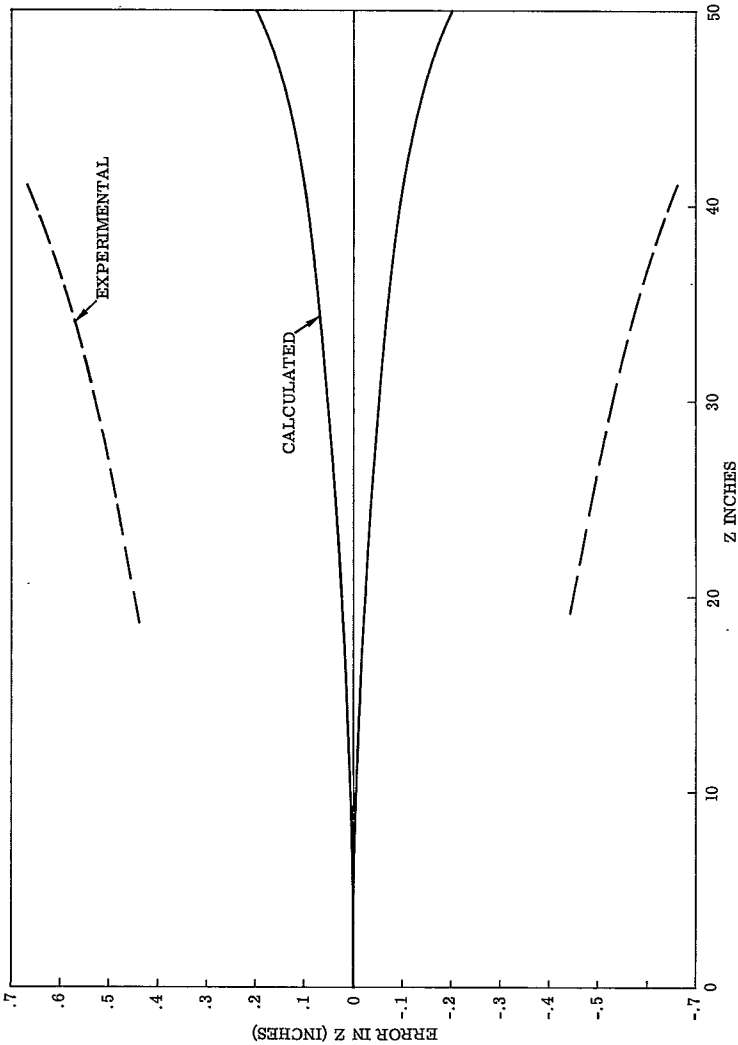


Figure 2-13. Readout Error Spread Calculated and Actual

Operator Slope and Point Measurements

In the perception test plan it was proposed to determine operator accuracy in measuring size and range of simple objects, using a stereo television system, as follows.

For each slide, the operator would measure in the stereo model the coordinates of each point on the metric, several points on a slope, and several points on a line. Knowing the dimensions of the original metric in the object space, a mathematical transformation between the geometry of the object space and the scaled down geometry of the stereo model space was to be computed for each slide-operator set of readings. The equations of the slope and line represented by the operator's point readings were then to be computed, transformed to the object space and the errors computed.

This was not practical because geometrical distortion of the stereo model, due to television nonlinearities, was more severe than anticipated. A computer program to perform transformations in the presence of such distortions was not practical within the scope of the control study.

A direct method of measurement was actually used. The operator placed a rod attached to a protractor on the slope, in the stereo model. The angle was recorded. He then placed the rod in the bottom plane of the metric and the angle was recorded. The angle between the two readings was the angle between the slope and bottom plane of the metric. While the effects of distortion still influenced the measurements, eye integration permitted much better results than point by point measurement, in the presence of local distortions.

The location of a line was measured in the stereo model by dropping a perpendicular, visually or with a small rod, from the bottom of the metric to a point on the line. The metric, marked in six inch segments, was used as a "yardstick" to read line locations directly.

Operator C, with the lowest standard deviation in the readout accuracy tests, made slope and point measurements for all 96 slides and for one additional slide which was a direct photographic stereo pair. Measurements are tabulated in Tables 2-2 and 2-3.

TABLE 2-2.
METRIC/SLOPE ANGULAR DIFFERENCE

	Metric Inclination		Slope Inclination		Metric Minus Slope Angle		
Slide No.	Reading	Actual	Reading	Actual	Reading	Actual	Diff
1	29.5	10	21.4	0	8.1	10	-1.1
2	34.5	10	24.9	0	9.6	10	-0.4
3	37.0	9	36.5	10	0.5	-1	1.5
4	37.5	17	25.5	10	12.0	7	5.0
5	25.1	10	20.1	0	5.0	10	-5.0
6	11.3	10	4.0	0	7.3	10	-2.7
7	20.5	9	17.5	10	3.0	-1	4.0
8	21.0	10	9.5	0	11.5	10	1.5
9	29.5	10	22.8	0	6.7	10	-3.3
10	31.2	17	20.5	10	10.7	7	3.7
11	38.5	10	30.5	0	8.0	10	-2.0
12	18.0	9	19.5	10	1.5	-1	2.5
13	10.2	9	4.6	10	5.6	-1	6.6
14	27.1	10	12.5	0	14.6	10	4.6
15	23.0	9	2.9	10	20.1	-1	21.1
16	6.8	10	2.4	0	4.4	10	-5.6
17	23.0	10	19.1	0	3.9	10	-6.1
18	34.0	17	29.7	10	4.3	7	-5.7
19	45.0	10	36.4	0	8.6	10	-1.4
20	15.5	17	6.2	10	9.3	7	2.3
21	29.5	9	29.5	10	0	-1	1.0
22	19.0	10	10.3	0	8.7	10	-1.3
23	27.5	10	19.5	0	8.0	10	-2.0
24	28.0	17	19.6	10	8.4	7	1.4
25	18.1	9	22.1	10	-4.0	-1	-3.0
26	26.0	10	14.5	0	11.5	10	1.5
27	23.9	10	13.7	0	10.2	10	0.2
28	28.0	10	19.5	0	8.5	10	-1.5
29	30.0	10	23.1	0	6.9	10	-3.1
30	25.0	9	23.6	10	1.4	-1	2.4
31	23.0	9	5.5	10	17.5	-1	18.5
32	1.3	14	9.4	11.5	-8.1	2.5	-10.6
33	24.5	9	26.6	10	-2.1	-1	-1.1

TABLE 2-2.
METRIC/SLOPE ANGULAR DIFFERENCE (CONT)

Slide No.	Metric Inclination		Slope Inclination		Metric Minus Slope Angle		
	Reading	Actual	Reading	Actual	Reading	Actual	Diff
34	31.2	10	21.6	0	9.6	10	-0.4
35	15.5	10	9.3	0	6.2	10	-3.8
36	11.9	10	5.4	0	6.5	10	-3.5
37	40.6	17	28.9	10	11.7	7	4.7
38	18.0	10	11.8	0	8.2	10	-1.8
39	32.8	10	23.9	0	8.9	10	-1.1
40	33.6	10	23.0	0	10.6	10	0.6
41	19.2	10	9.5	0	9.7	10	-0.3
42	27.8	10	18.5	0	9.3	10	-0.7
43	19.6	9	23.5	10	-3.9	-1	-2.9
44	24.4	9	26.7	10	-2.3	-1	-1.3
45	31.2	9	24.9	10	6.3	-1	7.3
46	18.4	10	16.9	0	1.5	10	-8.5
47	22.4	10	12.5	0	9.9	10	-0.1
48	24.5	10	15.5	0	9.0	10	-1.0
49	29.8	14	24.7	11.5	5.1	2.5	2.6
50	39.9	10	30.5	0	9.4	10	-0.6
51	29.2	10	23.0	0	6.2	10	-3.8
52	42.5	17	29.5	10	13.0	7	6.0
53	37.5	9	30.5	10	7.0	-1	8.0
54	29.9	10	28.9	0	1.0	10	-9.0
55	28.1	17	21.0	10	-7.1	7	-14.1
56	27.8	10	22.4	0	5.4	10	-4.6
57	29.9	10	35.7	0	-5.8	10	-15.8
58	39.5	17	26.2	10	13.3	7	6.3
59	24.8	9	23.2	10	1.6	-1	2.6
60	-	17	-	10	-	7	-
61	38.9	9	26.5	10	12.4	-1	13.4
62	32.5	9	30.5	10	2.0	-1	3.0
63	15.9	17	14.5	10	1.4	7	-5.6
64	13.0	10	7.1	0	5.9	10	-4.1
65	30.4	10	21.4	0	9.0	10	-1.0
66	21.0	9	12.7	10	8.3	-1	9.3

TABLE 2-2.
METRIC/SLOPE ANGULAR DIFFERENCE (CONT)

	Metric Inclination		Slope Inclination		Metric Minus Slope Angle		
Slide No.	Reading	Actual	Reading	Actual	Reading	Actual	Diff
67	43.4	17	30.4	10	13.0	7	6.0
68	40.7	17	26.9	10	13.8	7	6.8
69	21.0	10	12.3	0	8.7	10	-1.3
70	28.3	10	20.5	0	7.8	10	-2.2
71	38.7	10	30.6	0	8.1	10	-1.9
72	30.2	14	25.0	11.5	5.2	2.5	2.7
73	31.5	10	24.4	0	7.1	10	-2.9
74	21.5	10	11.0	0	10.5	10	0.5
75	33.0	17	22.0	10	11.0	7	4.0
76	35.4	17	25.7	10	9.7	7	2.7
77	32.8	17	29.5	10	3.3	7	-3.7
78	27.6	10	23.0	0	4.6	10	-5.4
79	38.0	9	40.7	10	-2.7	-1	-1.7
80	33.4	17	32.7	10	0.7	7	-6.3
81	38.0	17	30.4	10	7.6	7	0.6
82	33.8	17	29.5	10	4.3	7	-2.7
83	35.1	10	26.5	0	8.6	10	-1.4
84	18.1	10	8.0	0	10.1	10	0.1
85	28.5	9	29.3	10	-0.8	-1	0.2
86	28.4	10	21.5	0	6.9	10	-3.1
87	35.8	17	29.5	10	6.3	7	-0.7
88	21.9	10	12.5	0	9.4	10	-0.6
89	21.6	10	12.0	0	9.6	10	-0.4
90	27.9	17	20.9	10	7.0	7	0
91	26.0	17	20.3	10	5.7	7	-1.3
92	34.0	10	27.5	0	6.5	10	-3.5
93	25.9	9	29.0	10	-3.1	-1	-2.1
94	35.0	17	29.5	10	5.5	7	-1.5
95	29.6	17	22.6	10	7.0	7	0
96	19.6	10	6.9	0	12.7	10	2.7
97	30.0	17	21.3	10	8.7	7	1.7
97	29.6	17	21.6	10	8.0	7	1.0

TABLE 2-3.
DETERMINATION OF POINTS ON LINE

Slide No.	Point Relative to Metric Point 1			Point Relative to Metric Point 2		
	Z_{Read}	Z_{Actual}	$Z_R - Z_A$	Z_{Read}	Z_{Actual}	$Z_R - Z_A$
1	-	5.0	-	-	5.0	-
2	-	5.0	-	-	5.0	-
3	3.7	3.8	-0.1	2.7	2.2	0.5
4	-	5.0	-	-	1.5	-
5	3.5	5.0	-1.5	3.5	5.0	-1.5
6	4.5	5.0	-0.5	4.5	5.0	-0.5
7	-	3.8	-	-	2.2	-
8	-	5.0	-	-	5.0	-
9	3.5	5.0	-1.5	3.5	5.0	-1.5
10	0.6	5.0	-4.4	-1.5	1.5	-3.0
11	5.5	5.0	0.5	5.5	5.0	0
12	4.8	3.8	1.0	0.7	2.2	-1.5
13	-4.4	3.8	-8.2	-5.4	2.2	-7.6
14	3.5	5.0	-1.5	2.5	5.0	-2.5
15	-7.4	3.8	-11.2	-5.4	2.2	-7.6
16	3.5	5.0	-1.5	3.5	5.0	-1.5
17	1.5	5.0	-3.5	3.5	5.0	-1.5
18	3.7	5.0	-1.3	-0.5	1.5	-2.0
19	-	5.0	-	-	5.0	-
20	1.6	5.0	-3.4	0.6	1.5	-0.9
21	1.7	3.8	-2.1	0.7	2.2	-1.5
22	3.5	5.0	-1.5	3.5	5.0	-1.5
23	4.5	5.0	-0.5	4.5	5.0	-0.5
24	4.8	5.0	-0.2	0.6	1.5	-0.9
25	3.7	3.8	-0.1	2.7	2.2	0.5
26	5.5	5.0	0.5	3.5	5.0	-1.5
27	6.6	5.0	1.6	5.5	5.0	0.5
28	-	5.0	-	-	5.0	-
29	5.5	5.0	0.5	0.5	5.0	-4.5
30	-	3.8	-	-	2.2	-
31	-5.4	3.8	-9.2	-7.4	2.2	-9.6
32	1.7	3.5	-1.8	0.7	1.9	-1.2
33	3.7	3.8	-0.1	2.7	2.2	0.5

TABLE 2-3.
DETERMINATION OF POINTS ON LINE (CONT)

	Point Relative to Metric Point 1			Point Relative to Metric Point 2		
Slide No.	ZRead	ZActual	ZR - ZA	ZRead	ZActual	ZR - ZA
34	-0.6	5.0	-5.6	-0.6	5.0	-5.6
35	5.5	5.0	0.5	5.5	5.0	0.5
36	0.5	5.0	-4.5	0.5	5.0	-4.5
37	0.6	5.0	-4.4	-0.5	1.5	-2.0
38	5.5	5.0	0.5	5.5	5.0	0.5
39	3.5	5.0	-1.5	2.5	5.0	-2.5
40	2.5	5.0	-2.5	2.5	5.0	-2.5
41	3.5	5.0	-1.5	2.5	5.0	-2.5
42	6.6	5.0	1.6	5.5	5.0	0.5
43	4.8	3.8	1.0	3.7	2.2	1.5
44	5.8	3.8	2.0	3.7	2.2	1.5
45	0.7	3.8	-3.1	0.7	2.2	-1.5
46	-2.6	5.0	-7.6	-2.6	5.0	-7.6
47	6.6	5.0	1.6	4.5	5.0	-0.5
48	3.5	5.0	-1.5	3.5	5.0	-1.5
49	-	3.5	-	-	1.9	-
50	-	5.0	-	-	5.0	-
51	0.5	5.0	-4.5	1.5	5.0	-3.5
52	1.6	5.0	-3.4	-0.5	1.5	-2.0
53	-1.3	3.5	-4.8	-4.4	1.9	-6.3
54	2.5	5.0	-2.5	2.5	5.0	-2.5
55	-	5.0	-	-	1.5	-
56	-	5.0	-	-	5.0	-
57	4.5	5.0	-0.5	4.5	5.0	-0.5
58	0.6	5.0	-4.4	-1.5	1.5	-3.0
59	3.7	3.5	0.2	2.7	1.9	0.8
60	1.6	5.0	-3.4	1.6	1.5	0.1
61	-0.3	3.8	-4.1	-5.4	2.2	-7.6
62	3.7	5.0	-1.3	2.7	3.4	-0.7
63	2.7	5.0	-2.3	0.6	1.5	-0.9
64	1.5	5.0	-3.5	1.5	5.0	-3.5
65	3.5	5.0	-1.5	2.5	5.0	-2.5
66	-5.4	3.8	-9.2	-7.4	2.2	-9.6

TABLE 2-3.
DETERMINATION OF POINTS ON LINE (CONT)

Slide No.	Point Relative to Metric Point 1			Point Relative to Metric Point 2		
	Z_{Read}	Z_{Actual}	$Z_R - Z_A$	Z_{Read}	Z_{Actual}	$Z_R - Z_A$
67	2.7	5.0	-2.3	-1.5	1.5	-3.0
68	0.6	5.0	-4.4	-1.5	1.5	-3.0
69	4.5	5.0	-0.5	4.5	5.0	-0.5
70	6.6	5.0	1.6	6.6	5.0	1.6
71	3.5	5.0	-1.5	3.5	5.0	-1.5
72	4.8	3.5	1.3	1.7	1.9	-0.2
73	4.5	5.0	-0.5	4.5	5.0	-0.5
74	3.5	5.0	-1.5	1.5	5.0	-3.5
75	4.8	5.0	-0.2	0.6	1.5	-0.9
76	3.7	5.0	-1.3	3.7	1.5	2.2
77	2.7	5.0	-2.3	0.6	1.5	-0.9
78	3.5	5.0	-1.5	3.5	5.0	-1.5
79	0.7	3.8	-3.1	-4.4	2.2	-6.6
80	0.6	5.0	-4.4	-1.5	1.5	-3.0
81	2.7	5.0	-2.3	0.6	1.5	-0.9
82	2.7	5.0	-2.3	0.6	1.5	-0.9
83	2.5	5.0	-3.5	2.5	5.0	-2.5
84	4.5	5.0	-0.5	4.5	5.0	-0.5
85	-	3.8	-	-	2.2	-
86	6.6	5.0	1.6	5.5	5.0	1.5
87	0.6	5.0	-4.4	0.6	1.5	-0.9
88	4.5	5.0	-0.5	2.5	5.0	-2.5
89	5.5	5.0	1.5	1.5	5.0	-3.5
90	4.8	5.0	-0.2	0.6	1.5	-0.9
91	3.7	5.0	-1.3	0.6	1.5	-0.9
92	1.5	5.0	-3.5	0.5	5.0	-4.5
93	-0.3	3.8	-4.1	-1.3	2.2	-3.5
94	2.7	5.0	-2.3	0.6	1.5	-0.9
95	4.8	5.0	-0.2	1.6	1.5	0.1
96	1.5	5.0	-3.5	0.5	5.0	-4.5
97	3.7	5.0	-1.3	1.6	1.5	0.1

Television Geometrical Distortion

The general problem of television geometrical distortion and its effects on the stereo model is very complex and will not be treated here. The effects of a single nonlinear sweep or scan in each member of a stereo pair are considered in order to determine the portion of total error in the perception tests which can be attributed to this cause.

The closed circuit television system utilized in the perception tests was used to photograph an accurate grid placed perpendicular to the optical axis. A photograph of the grid, as it appeared on the monitor, was measured along one scan line through the center of the image. The resulting curve of horizontal linearity is shown in Figure 2-14. Maximum nonlinearity was 5.5% which is typical of commercial closed circuit systems. Maximum local distortion was 0.66% over approximately 10% of the sweep. It was this local distortion which affected measurement accuracy most seriously.

Measurements of horizontal linearity for the closed circuit television system used for the SLRV vehicle control tests showed a maximum overall distortion of 5.6%.

Linearity of the television system proposed for SLRV will be at least an order of magnitude better than that of the commercial systems used for the SLRV Control Study.

Figure 2-15 shows the stereo geometry involved, for a point on a plane through the camera optical axes. From camera positions L and R, point P is located at the intersection of line LP and RP. The lines form angles A and B with the baseline. Assume that, due to local distortion, the point is recorded and reproduced in the stereo model at the intersection of lines LP' and RP'. The error Δ Z in depth is due to angular changes Δ A and Δ B.

Since linearity is usually expressed in percent, the angular values of Δ A and Δ B will be a percentage of camera field angle. Then, for a given percentage distortion, the effect of angular distortion on a stereo model will increase with field angle of the television camera.

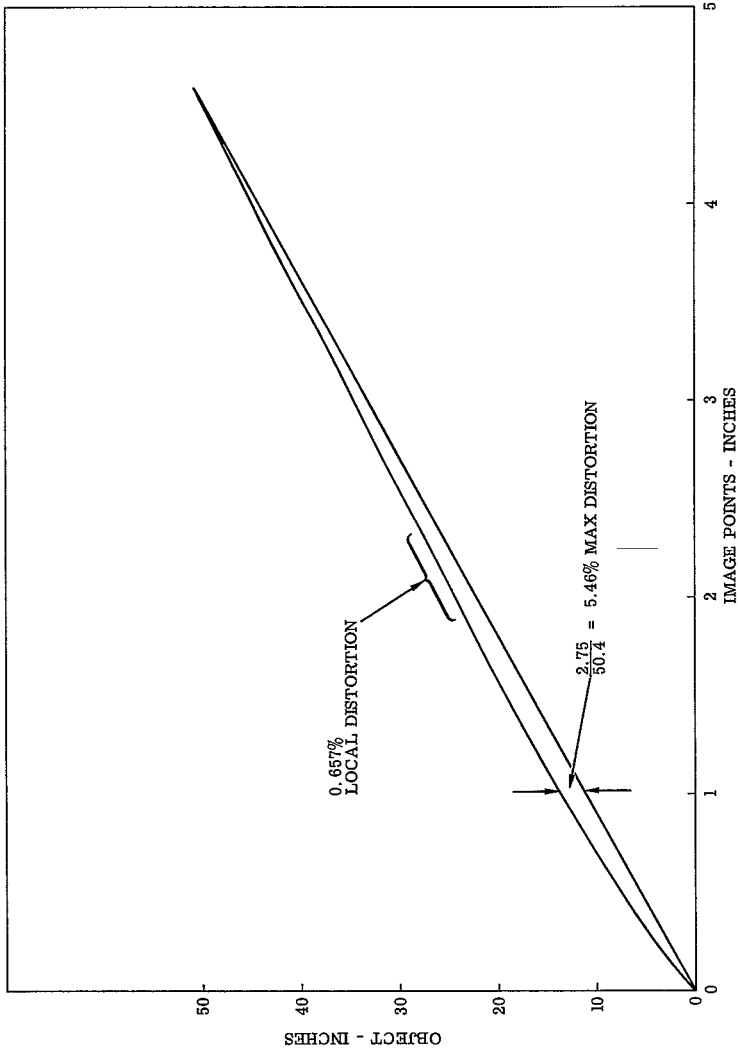


Figure 2-14. Television System Horizontal Linearity on Axis

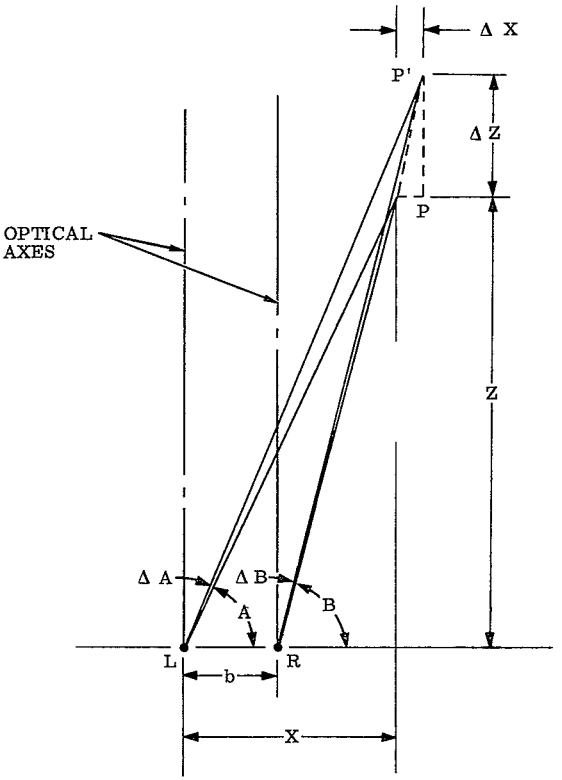


Figure 2-15. Depth Distortion Due to Nonlinear Scan

For the sake of simplicity, assume a special worst case where the object point lies midway between the two optical axes and $\triangle A = \triangle -B$. Then

$$\triangle Z = \frac{b}{2} \text{ Tan } (A + \triangle A) - Z$$

Using this equation, range error values given in Table 2-4 were calculated. The variables were percent distortion, range of a point, length of baseline, and field angle.

Effects of Parametric Variations

The operator readout range error curves shown in Figure 2-13 for the stereo model space are shown in Figure 2-16 with the scale expanded for object space. For example, the curves in Figure 2-13 extend in range (2) from 20" to 40" with an error spread of about ± 0.5". In object space using a 5-inch baseline, they are shown in Figure 2-16 extending from 40" to 80" with an error spread of about ± 1". For a 9-inch baseline, where the scale ratio is 3.6, the curves extend from 72" to 144" with an error spread of about ± 1.8".

The maximum range error curves shown in Figure 2-16 for 5-inch and 9-inch baseline represent maximum values for all other parameters, good and bad, from Table 2-3. The question is - what are the sources of the differences between maximum readout error and maximum error in determining range of points? Comparison with the values in Table 2-4 shows the difference to be almost entirely due to television distortion.

The values of standard deviation given in Tables 2-5 and 2-6 were computed as discussed previously.

In Table 2-5 the range errors from Table 2-3 for all 96 slides were separated by parameter variations, one parameter at a time, and the standard deviations (σ) calculated. For example, the 96 slides were separated into those with 90-inch subject distance and 108-inch subject distance and the two values of σ calculated.

Parametric effects due to interacting parameters can be deduced from the data. The method of achieving the two resolutions, or number of scan lines, involved changing the field angle of the television system. Therefore, the reduction

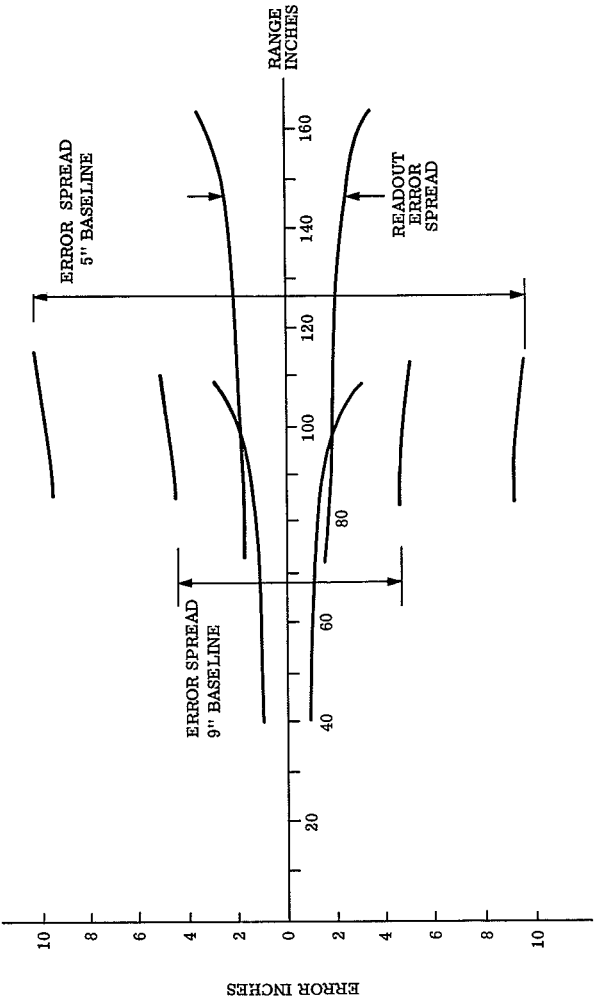


Figure 2-16. Range Error in Estimating Points

TABLE 2-4.

RANGE ERROR SPREAD DUE TO NONLINEARITIES

% Distortion	Field Angle	b (baseline)	Range 5'	Range 10'	Range 15'	Range 20'
0.05	22-1/2	5"	0.3"	1.1"	2.5"	4.4"
0.05		9"	0.2"	0.8"	1.4"	2.4"
0.10		5"	0.5"	2.4"	5.3"	9.5"
0.10		9"	0.3"	1.4"	2.9"	5.2"
0.15		5"	0.9"	3.4"	8.0"	14.5"
0.15		9"	0.5"	1.9"	4.4"	7.8"
0.20		5"	1.2"	4.7"	10.1"	19.8"
0.20		9"	0.7"	2.6"	5.9"	10.5"
0.25		5"	1.3"	5.4"	12.3"	22.2"
0.25		9"	1.2"	2.9"	6.6"	11.9"
0.50		5"	2.7"	10.5"	25.0"	48.0"
0.50		9"	1.9"	5.5"	13.0"	25.5"
0.05	45°	5"	0.5"	2.4"	4.3"	9.5"
0.05		9"	0.3"	1.4"	3.0"	5.5"
0.10		5"	1.2"	4.7"	8.7"	19.8"
0.10		9"	0.7"	2.5"	5.7"	13.0"
0.15		5"	1.8"	7.3"	16.9"	30.9"
0.15		9"	0.8"	3.7"	8.5"	16.0"
0.20		5"	2.4"	9.8"	22.9"	42.7"
0.20		9"	1.4"	5.0"	12.0"	19.5"
0.25		5"	2.9"	12.2"	28.8"	54.2"
0.25		9"	1.7"	6.5"	14.8"	25.0"
0.50		5"	6.3"	24.0"	69.0"	143.0"
0.50		9"	3.4"	13.2"	33.0"	57.7"

in σ apparently due to increased resolution in Table 2-5 might be due to field angle change from Table 2-4. Indeed, the σ change is about equivalent to that due to field angle change in Table 2-4. Thus, at the short ranges involved, resolution seems to play a minor role.

Much further analysis of the effect of parametric variations remains to be done.

TABLE 2-5.

STANDARD DEVIATION FOR PARAMETER VARIATIONS

Parameter	Point 1-σ	Point 2-σ	Slope σ
d = 90"	2.3"	2.3"	4.3°
d = 108"	4.4	2.7	7.2
b = 5"	4.3	4.1	6.5
b = 9"	1.9	2.0	4.0
Complexity #1	2.9	2.5	5.1
Complexity #2	1.2	3.7	6.7
Complexity #3	3.1	3.3	3.9
Grey Scale 1	2.5	2.8	5.0
Grey Scale 2	3.9	3.9	5.7
Resolution 1	3.8	3.9	6.4
Resolution 2	2.8	2.7	4.2
S/N #1	3.4	3.0	6.0
S/N #2	3.2	3.4	4.7

TABLE 2-6.

STANDARD DEVIATIONS FOR PARAMETER VARIATIONS

Parameter	Point 1-σ	Point 2-σ	Slope σ
$\alpha = 11^o$	3.7	4.0	5.9
17^o	1.9	2.1	4.1
$\beta = 0^o$	2.0	1.9	3.6
45^o	2.7	3.0	4.7
90^o	4.6	4.2	5.6
$\gamma = 0^o$	2.5	2.7	4.0
15^o	4.9	4.7	7.9
30^o	2.8	2.5	5.1
b = 5", RES = 1	5.2	5.0	8.0
b = 5, RES = 2	3.5	3.2	4.6
b = 9, RES = 1	2.0	1.8	4.1
b = 9, RES = 2	2.0	2.4	4.0

SECTION III

VEHICLE CONTROL TESTS

OBJECTIVES

The vehicle control test program was designed to investigate the problems associated with remote control of an SLRV, with a television system as prime sensor, by actually maneuvering a vehicle over various forms of terrain. In establishing this program, efforts were made to simulate the present concepts of vehicle design, operating ground equipment, and the control philosophy to the extent possible consistent with the scope of the Control Study. The test program had six basic objectives:

- To evaluate the ability of a vehicle controller to maneuver a remotely controlled SLRV ETM over a clearly defined test course.
- To evaluate the ability of a vehicle controller to maneuver a remotely controlled ETM to a predefined point over a terrain containing slopes, crevices, tank trap obstacles, and step obstacles.
- To evaluate the effects of perceptive aids in a vehicle controller's performance.
- To estimate the control margin to be used in deriving the SLRV effective safe mobility.
- To provide preliminary data on operator decision times for use in establishing mission times.
- To provide initial data for substantiating or modifying OGE concepts.

ORGANIZATION

To properly evaluate the elements associated with remote control, a test program must exercise the control loop as much as possible. In organizing the vehicle test program, a combination of open field operation and maneuvering on specifically designed test courses was felt to offer the most complete analysis of the test objectives. Therefore, a three-phase program was established which consisted of roadway, tank trap, and general lunarium tests.

Roadway Tests

The roadway tests were conducted on a well defined course where the vehicle controller maneuvered the ETM on a "road" between right and left boundary markers. The course, shown in Figure 3-1, was 582 feet long, contained 18 curves ranging in center radius from 5 to 14 feet, and was 3.5 to 5.5 feet wide. The roadway was laid out in a portion of the lunarium which contained large rocks and a long side slope.

This type of a test course enables a fairly comprehensive analysis of the vehicle-ground equipment-driver loop, since it not only requires a high degree of precision maneuvering, but also provides a means of scoring or grading the loop. Grading performance was accomplished by noting the location on the roadway edge where any of the ETM tires made contact with, or went outside, the boundary markers. As an aid in evaluating performance, the course was marked off into 29 segments or zones. The roadway characteristics for each zone are shown in Table 3-1. To present the operator with as many control decisions as possible, over 55% of the course (330 linear feet) was curved, and six zones (5 curves and 1 straightaway) were located on the side slope.

The areas of particular interest during this phase of vehicle testing were:

- The control problems encountered by an operator over a one to three step distance.
- The effects of step-steering and step-motion on vehicle control.
- The relative merits of different camera/system configurations.
- The command and vehicle rates demonstrated by various operators and configurations.
- The effects of slip, slide, and obstacle crossing upon path prediction.

Tank Trap Tests

The tank trap tests were used primarily to evaluate control problems encountered when operating in a highly adverse terrain. A tank trap obstacle course was selected because this type of terrain maximizes the control problem and the quantity of critical decisions required by the operator. During these tests, the

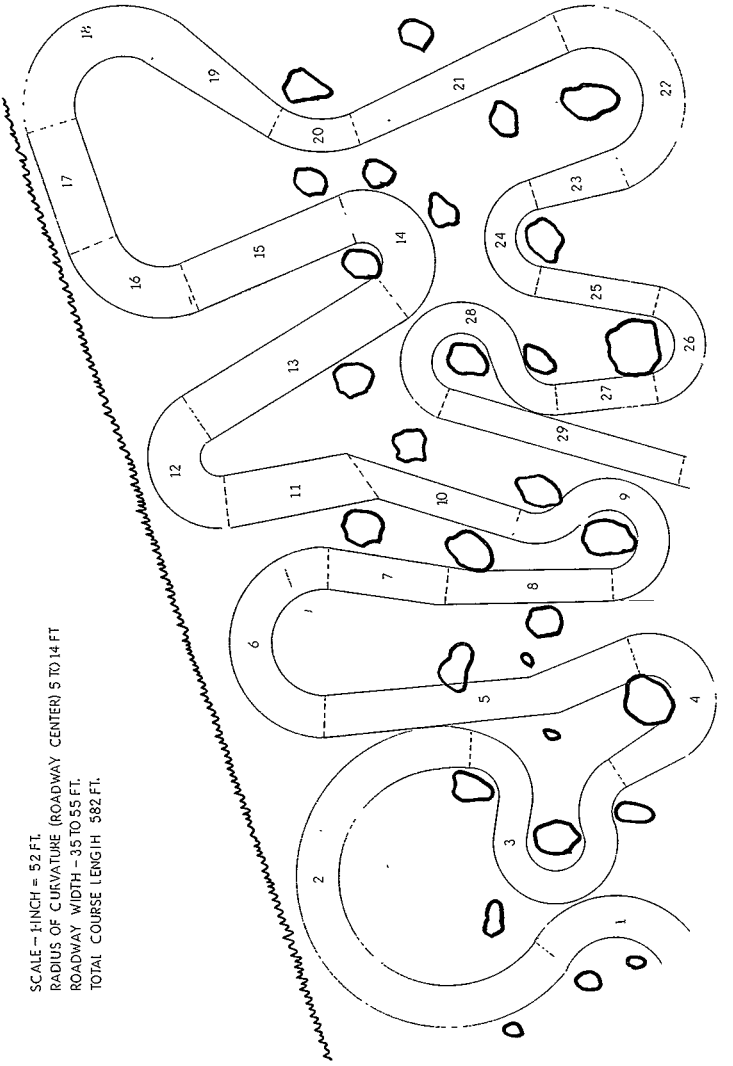


Figure 3-1. Roadway Test Course

TABLE 3-1.

ROADWAY COURSE CHARACTERISTICS

Section	Center Radius	Width	Length
1	8 feet	4.5 feet	21 feet
2	14	4.5	58
3	5	3.5	37
4	5	3.5 - 4.5	21
5	--	4.5	34
6	8	4.5	25
7	--	4.5	12
8	--	4.5 - 3.5	17
9	5	3.5	26
10	--	3.5	17
11	--	5.5	15
12	5	5.5	13
13	--	5.5	24
14	5	5.5	14
15	--	5.5	18
16	8	5.5	12
17	--	5.5	13
18	8	5.5	19
19	--	5.5 - 3.5	15
20	10	3.5	9
21	--	3.5 - 4.5	24
22	8	4.5	24
23	--	4.5 - 3.5	10
24	5	3.5	13
25	--	3.5	13
26	5	3.5	13
27	--	3.5	10
28	5	3.5	28
29	--	3.5	27

operator was presented with severe maneuvering problems, and the requirement to measure and evaluate the obstacles in his path.

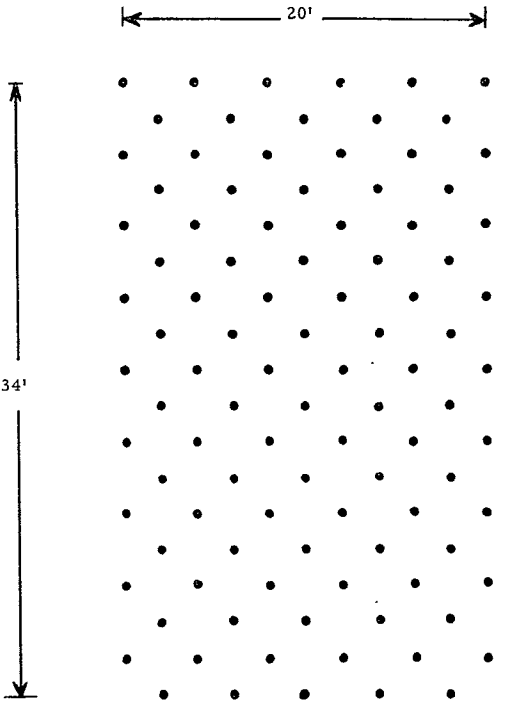
The course itself was laid out on a 20-foot by 34-foot flat portion of the lunarium. Ninety-nine obstacles ranging from 5" to 11" in height were placed in a semi-uniform pattern such that no straight path existed from one end of the field to the other. The attitudes of the obstacles within the field were randomly distributed ±45° from vertical to further reduce any uniformity presented to the controller. Figure 3-2 shows the basic layout of the tank trap course.

The problem presented to the vehicle controller was to study the field from one end using the vehicle TV, select a path, and maneuver the ETM through the field in the 34-foot direction without climbing obstacles or hanging up the vehicle. The data obtained from this test phase was to be used to:

- Evaluate problems in path selection and vehicle maneuvering while in hazardous terrain
- Evaluate perceptive aids
- Verify the estimated perception margin
- Evaluate the effects of step-steering and step-motion on control; and
- Estimate the SLRV perception margin

General Lunarium Tests

The third and final phase of vehicle testing was a simulation, under the limitations of the study, of the lunar operation of vectoring the SLRV from one intermediate objective (IO) to another via a series of short range objectives (SRO's). These open-field tests were used to evaluate the general problems of control presented by test courses containing various terrain features such as crevices, rocks, slopes, step obstacles, tank trap obstacles, and flat surfaces. During these tests the operator was required to measure heights, widths, and depths, assess terrain features, perform vehicle orientation maneuvers, select the best path to an SRO, and maneuver the vehicle along the selected path.



Each dot represents the location of a tank trap object

Coordinates of each point are:

x = n24 ± 6 inches

y = m24 ± 6 inches

Obstacle angles = 90° (vertical) to 45°

Figure 3-2. Tank Trap Field Layout

Figure 3-3 is a drawing of the major features in the test section of the GM DRL lunarium and the four courses used for these tests. Figure 3-4 is a photograph of this same area. Courses 1, 2, and 3 required the operator to drive the ETM over slopes and crevices, while course 4 was laid out to bypass all mobility obstacles. The SRO's were predefined and marked on the lunarium to provide the controller with a visual heading or target in his TV picture.

Specific objectives of the general lunarium tests were to:

- Estimate the SLRV control margin
- Evaluate the problems of SLRV control using TV during a simulated mission
- Obtain decision time and vehicle rate data
- Evaluate perceptive aids
- Evaluate the effects of step-motion and step-steering on control; and
- Verify the estimated perception margin

EQUIPMENT

Vehicle

The vehicle used for the control tests was the Engineering Test Model (ETM) fabricated by GM DRL during the SLRV Phase I program and subsequently delivered to Jet Propulsion Laboratories. Several additions/modifications were required to update the ETM configuration so that it could be used for remote control tests. The major change was the addition of a television camera and control unit. Figure 3-5 shows the configuration of the ETM after the modifications were made.

In approaching the problem of providing a stereo television presentation to the vehicle controller, the trade-offs between a one- and a two-camera system were examined and the decision was made to use a single camera (Figure 3-5) with a split screen optical attachment to achieve stereo. The television system selected was a Cohu Model 2001-011 camera with a Model 7263A ruggedized vidicon and a Model 200-100 camera control unit. The stereo attachment was designed and built at GM DRL and consists of four mirrors which provide a

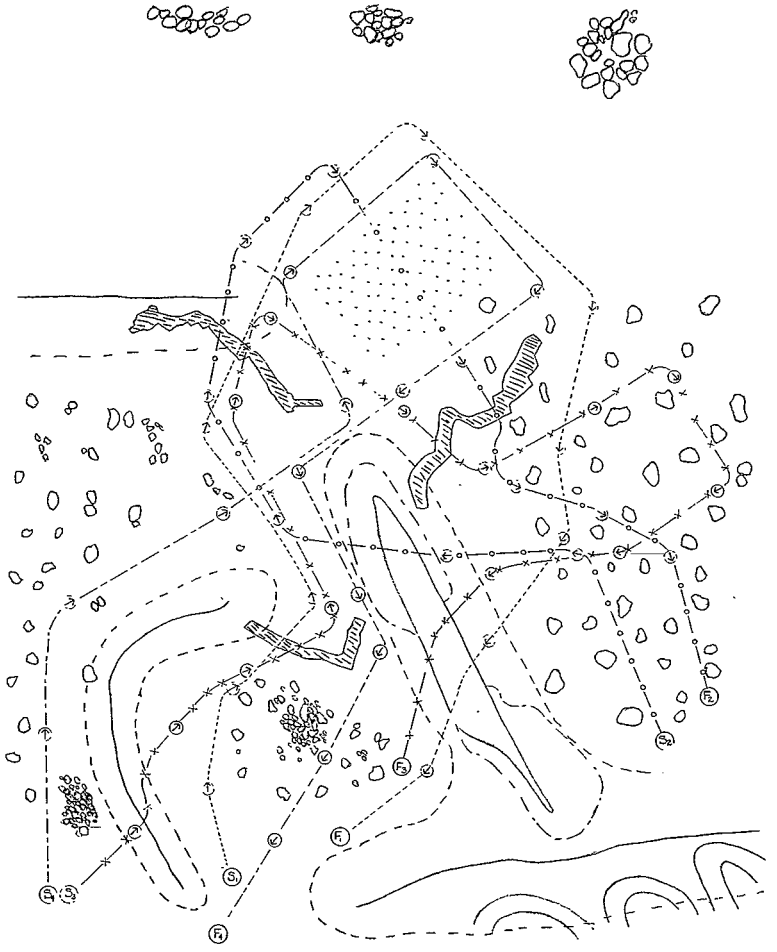


Figure 3-3. General Lunarium Courses

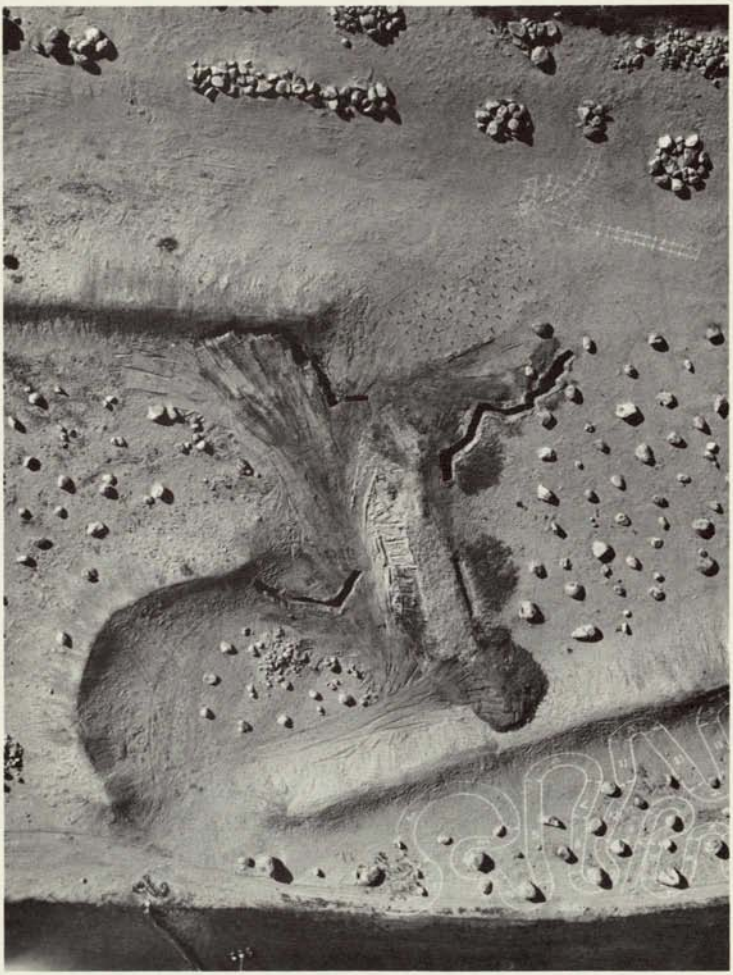


Figure 3-4. Photograph of the General Lunarium Test Area Including the Tank Trap Field and Part of the Roadway

76

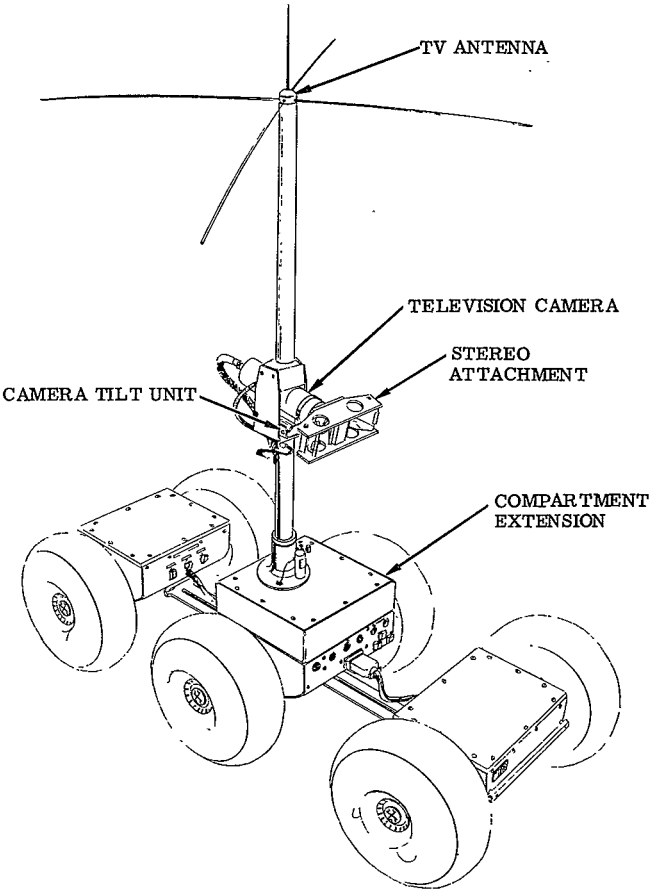


Figure 3-5. ETM Configuration

right and left eye image to the vidicon. The two input mirrors are spaced to provide an equivalent stereo baseline of five inches and have alignment adjustments, while the two output mirrors are fixed at assembly. The TV camera/stereo attachment provides a system with the following characteristics:

Baseline - 5 inches

Vertical Field of View - 40 degrees

Horizontal Field of View - 24 degrees

Optical Axes - parallel

Scan Lines - 525

To provide full remote operation, the camera control unit was procured with a low power r-f transmitter operating on Channel 6. The design is such that a simple conversion to closed circuit operation can be made in a matter of minutes if necessary. The r-f output from the camera control unit is connected to a quarter wave stub antenna with a ground plane.

In evaluating the position controls for the camera, a tilt capability was considered desirable in addition to a pan capability. The tilt feature however, was felt to be secondary in nature for these control tests, and therefore a manual three-position adjustment was provided. The pan controls were designed to give complete 360° coverage of the terrain around the vehicle. In mechanizing the pan system, the camera horizontal view angle, the primary operating camera positions, perceptive aids, and the existing ETM control system were considered. The steering logic in the ETM provides the basic commands necessary to control a camera pan system, namely, step right, step left, full right, full left, and return to center. By utilizing one of the two spare commands in the ETM control transmitter/receiver system to transfer the steering commands to the pan control system, all functions necessary to operate the pan controls are available. The pan controls use a cam-switch arrangement similar to those found in the steering controls except that 360° rotation is provided rather than ±30°. The logic system in the ETM was slightly modified to provide the following pan controls:

ENTER PAN MODE - Transfer of the steering controls to pan mode is accomplished by issuing the PAN command. This command is new and utilizes a previously spare channel.

EXIT PAN MODE - Transfer of the steering controls back to steering mode is accomplished by issuing the STOP command.

CENTER CAMERA - By issuing the CENTER command while in pan mode, the camera is driven until the optical axis is in line with the vehicle center axis looking forward.

PAN RIGHT OR PAN LEFT - By issuing a STEP RIGHT or STEP LEFT command, the camera is panned right or left through a fixed angle. Two different fixed angles were selected to provide maximum terrain coverage where required. The two steps right and left of center, and the two steps right and left of center rear are 12° and the remaining steps are in 22° increments. The 12° steps about the front and rear allow the overlap necessary for good control and perceptive aid interpretation, while the 22° steps allow complete adjacent coverage of the remaining field.

PAN FULL RIGHT OR PAN FULL LEFT - Because of a cable between the camera and the vehicle, continuous rotation of the camera is not possible. For this reason and to reduce the time to achieve large pan angle motion, a FULL RIGHT or FULL LEFT command is used to pan the camera to stops located at the 156° position.

The remote control pan system required the addition to the ETM of an integrator-amplifier, two one-shop multivibrators, two relay drive amplifiers, one bi-stable relay, two control switching relays, four cam-switch assemblies, and a drive motor.

The center compartment was selected as the location for the camera system. This decision was based upon several factors. Having the TV on the center compartment, rather than the front or rear one, eliminates rotation of the camera during steering. This, in itself, reduces the operator orientation problem (relationship of the vehicle with the viewed terrain) and significantly reduces the number of perceptive aids required by making the aids independent of end compartment orientation. The center compartment location also reduces the effect of the narrow viewing angle of the camera when the stereo attachment is used, by providing an additional 27 inches between the camera and the front of the vehicle. Lastly, the weight distribution of the ETM is better and more

controllable from mobility considerations with the added weight on the center compartment. The camera, TV antenna, and command receiver antenna are located on a mast, and the mast assembly is mounted to a four-inch extension to the center compartment. This extension houses the pan logic, pan controls, and the camera control unit. Camera rotation is accomplished by rotating the entire mast assembly.

Two other vehicle modifications were made which greatly improved the ETM operation for the purposes of these tests. One was the addition of a braking system to keep the vehicle from rolling on slopes. Mercury switches were used to sense a center compartment pitch angle of greater than 5° and the direction of the pitch (up or down). When such an angle is measured, a reduced voltage of proper polarity is applied to the six wheel-drive motors. This voltage is removed during steering and motion maneuvers. The other modification was to apply power to the front and rear wheels during steering. The polarity of the applied voltage is such as to drive the outside wheels away from the vehicle and the inside wheels toward the vehicle. This dynamic steering prevents scuffing and enables the wheels to climb relatively small obstacles during steering. Table 3-2 lists the vehicle and vehicle related equipment used during the control tests.

TABLE 3-2.

ETM AND ETM-RELATED EQUIPMENT USED IN CONTROL TESTS

	Item	MFR/Source	Model	GM DRL Facility Item
1.	Television Camera	Cohu Elect. Inc	2000-011	No
2.	Camera Control Unit	Cohu Elect. Inc	2000-100	No
3.	Camera Stereo Attachment	GM/DRL	NA	No
4.	Battery Charger	GM/DRL	NA	No
5.	Control Transmitter	GM/DRL	NA	No
6.	Carrying Rack	GM/DRL	NA	No

Ground Support

The ground support equipment for the vehicle test program consisted of an operator's console, a test conductor's console, a closed circuit TV camera, communications devices and, for general lunarium tests, a plan view board. Figure 3-6 is a photograph of the control room equipment.

The operator's console contains a Cohu GRM-17R 17-inch closed circuit TV monitor, split field stereo viewing optics, a perceptive aid generator and controls and a vehicle command transmitter and controls. These items are mounted in a sit-down, sloped front, single bay cabinet with a shelf. The TV monitor is mounted in the sloped portion of the cabinet and a box-type housing approximately 17" x 15" x 12" is attached to the cabinet over the monitor screen. This housing contains the stereo viewing optics and the perceptive aid generator. The stereo optics consists of a separator and four mirrors, two of which are adjustable to provide proper left and right-eye image spacing to the operator. Introduction of perceptive aids to the television

image is accomplished by side illumination of plexiglass sheets into which the aid markings have been cut. The inscribed sheets are mounted at right angles to the TV monitor face and the images are projected into the TV picture through a half-silvered mirror. Up to four different aids can be mounted in the housing and individually illuminated by a two-switch control system.

Both two- and three-dimensional aids were made for use during the test program. The two-dimensional aids consisted of three sheets showing projected vehicle tire tracks for straight-ahead monoscopic camera viewing, marked off in one-half wheel revolution steps for (1) straight-ahead steering, (2) right turn steering of 7-1/2°, 15°, and 22-1/2°, and (3) left turn steering of 7-1/2°, 15°, and 22-1/2°. The three-dimensional aids consisted of four sheets showing (1) a measurement grid for any camera azimuth angle, (2) straight-ahead tire tracks for center camera viewing, (3) right turn tire tracks for a 12° right of center camera position, and (4) left turn tire tracks for a 12° left of center camera position. Due to the viewing symmetry provided by the center compartment mounting of the camera, the steering aids (tire tracks) were also valid for rear camera viewing positions. To compensate for distortion in the TV and inaccuracies in the steering and camera cam-switch systems, the aids were fabricated in a closed loop fashion. The subject (tire tracks or measurement

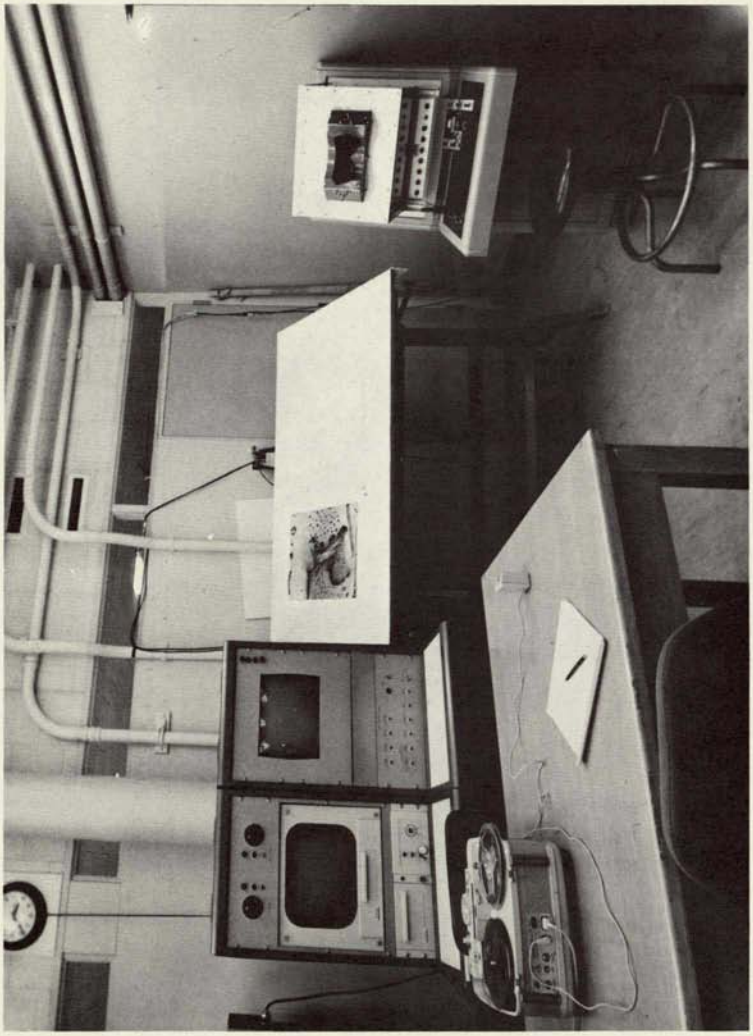


Figure 3-6. Control Room Layout

grid) was marked off on a flat surface in front of the vehicle and viewed by the vehicle camera. The locations of markings on the aid were then varied until the projected aid and the markings in front of the vehicle were coincident in the monitor. The resultant aids were then cut into the plexiglass.

The control transmitter originally delivered with the ETM was mounted in a depression cut into the cabinet shelf, thus allowing easy removal. The control unit was modified to issue a previously unused tone for commanding "pan mode."

The test conductor's console used for these tests was an existing two-bay monitor group. This console contains a closed circuit TV monitor and associated controls connected to a TV camera located on the roof of the GM DRL engineering building. The monitor was used by test personnel to follow the progress of the vehicle. Also contained in the console is a commercial television receiver. This set was used to display the vehicle TV picture to the test personnel and to provide the video and necessary sync signals to the operator's console. The video signal is run through a switch so that the operator's picture can be removed when the vehicle is moving or the vehicle camera is being panned.

The balance of the ground support equipment consisted of an audio tape recorder for recording operator and test personnel commentary, two transceivers for communications with a field observer, a Channel 6 receiving antenna, a vertically polarized quarter-wave stub antenna with a ground plane for transmission of commands to the vehicle, and a plotting board. The plotting board was used during general lunarium tests to show a plan view of the terrain characteristics and the vehicle path. Using an aerial photograph of the test area as an underlay, those terrain features which were viewed through the vehicle TV were drawn on a sheet of paper along with the vehicle path. This drawing was made available to the operator for orientation purposes.

The control and communications flow is shown in Figure 3-7; Table 3-3 is a listing of the GSE used for these tests.

OPERATORS

Three operators were used for the control tests and each operator controlled the vehicle during the roadway, tank trap, and general lunarium phases. Two

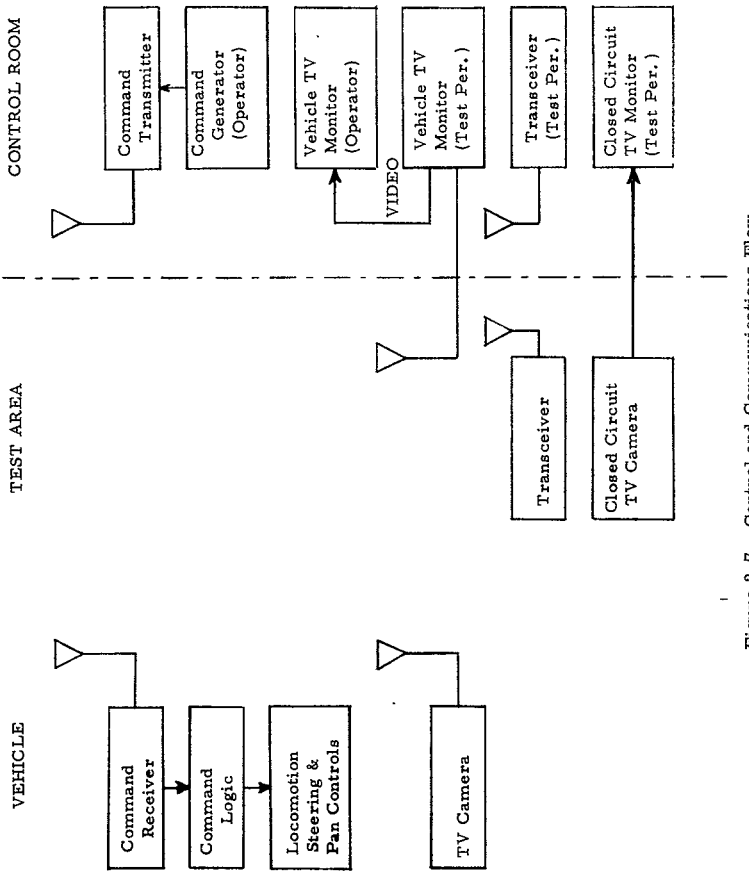


Figure 3-7. Control and Communications Flow

TABLE 3-3.

GROUND SUPPORT EQUIPMENT USED IN CONTROL TESTS

	Item	MFR/Source	Model	GM DRL Facility Item
1.	Television Monitor	Cohu, Kintel	GRM-17R	No
2.	Television Monitor	RCA	KCS141-21	Yes
3.	Television Monitor	Cohu, Kintel	GRM-14R	Yes
4.	Television Camera	Cohu, Kintel	1995CS	Yes
5.	Television Control Unit	Cohu, Kintel	1995CU	Yes
6.	Pan/Tilt Unit	Cohu, Kintel	ARC-14HX	Yes
7.	Television Receiving Antenna	Winegard	K-10-06	No
8.	Transmitting Antenna	GM/DRL	NA	No
9.	Tape Recorder	Revere	T-2200	Yes
10.	Radio Transceiver, 2 ea	Heath Kit	NA	Yes
11.	Plotting Table	GM/DRL	NA	Yes
12.	Control Console			
	a. Perceptive Aid Adapter	GM/DRL	NA	No
	b. Stereo Attachment	GM/DRL	NA	No
	c. Perceptive Aids	GM/DRL	NA	No

of the operators were selected from the Control Study personnel and were quite knowledgeable in terms of the vehicle, the Control Study, and the SLRV program in general. The third operator was one of the perception test subjects and did not have normal contact with the program. This subject did, however, have some experience in driving the Control Model. A fourth person, who was also a perception test subject, was to be used as an operator but was dropped after one roadway test due to the uncertainty and nervousness he exhibited while driving the vehicle.

PROGRAM CONSTRAINTS

The test program was conducted in the presence of certain constraints which limited the extent to which a true simulation of an actual and/or envisioned SLRV operation could be made. While these constraints did not present major problems, they no doubt had an effect on the results. During the analysis phase, allowances were made for these factors where appropriate, which in general would contribute to a lessening of the efficiency and the control accuracy to be found in an operational configuration.

Vehicle

The major control limitation imposed by the vehicle system was the narrow field of view of the TV when the stereo attachment was used. A horizontal field angle of 24° did not present the operator with terrain definition desirable for selecting steering other than straight ahead. This was compensated for by 12° pan steps around center, but the operators had some difficulty trying to piece several pictures together by memory.

Ground Support Equipment

The majority of the operating constraints existed in the ground support equipment (GSE) area. For the operational case, the GSE will be far more sophisticated than could be accomplished within the scope of the Control Study. The key factors missing from the GSE were as follows.

PICTURE RECALL - A means of selecting and viewing previously taken TV pictures will be of significant assistance to the vehicle controller. This is particularly true when the operator is in a difficult control situation and is attempting to orient himself with respect to terrain features no longer in his field of view. During the vehicle tests, previous pictures would have been very useful to the operator when negotiating certain roadway turns, when selecting a path through and when traversing the tank trap field, and when aligning the vehicle for crevice crossing during general lunarium tests. The extent of improvement which would have been noted with picture recall is not known but it certainly would have been significant.

IMPROVED PERCEPTIVE AIDS - The perceptive aids used for these tests, while of considerable value in driving the vehicle, lacked flexibility. The steering aids were valid for only certain camera azimuth angles and, due to the field of view (particularly the stereo system), encompassed only the outside tire track for most steering angles. Aids for camera angles of ±12° and ±24° for monoscopic TV, and ±24° for stereo TV would have been of significant value during tight turn situations. Further, the aids were valid for flat ground only, which necessitated interpolation by the operator when operating on slopes. As with picture recall, a flexible set of perceptive aids would certainly have improved performance, but the magnitude is unknown.

DISPLAY AIDS - No display aids, other than the TV picture, were available to the controller to assist him in orienting himself. Displays such as camera azimuth, steering angles, vehicle roll and pitch angles, azimuth angle to objective, and distance to objective would have been quite helpful. The effects of not having this information were not as significant as the previously mentioned factors, but did contribute to some excessive steering and camera panning. For example, cases of an operator issuing a STEER CENTER and STEP STEER LEFT command to achieve 7.5° left steering when that steering existed originally were quite common. Another fault, which was easily corrected in the data, occurred when the operator issued steering and motion commands based upon camera azimuth angles which were incorrect, generally causing "errors." This type of failure would not have happened in the operational case with properly mechanized perceptive aids and a Mobility Checkout Section to verify commands.

Operators

The human element was a major factor in the control loop during the vehicle tests. Certain elements associated with the operators and their role had effects of various magnitudes on the tests as compared to an operational situation. While two of the operators were familiar with the vehicle and the program, a formal training course including vehicle characteristics and motion, photo interpretation, command efficiency, and actual driving experience would no doubt have improved the results. The second major factor was operator motivation. No reward-penalty system was employed and certainly the operator's concern for the vehicle did not match that which would be exhibited if he were maneuvering the vehicle on the moon. This factor would tend to increase

both the efficiency and the number of observed "errors" during the test program even though each operator made a positive effort to reduce these effects.

TEST RUN SUMMARY

The number of vehicle tests performed during the Control Study, along with a few pertinent facts, are shown in Table 3-4.

TABLE 3-4.

TEST RUN SUMMARY

Test Phase	No. of Tests	Configurations*				Distance Traveled	Commands Issued
		M	MA	S	SA		
Roadway	24	X	X	X	X	4000 meters	22,363
Tank Trap	18				X	174 meters + survey	5,992
General Lunarium	12				X	1360 meters	8,178

*Configurations

M - Monoscopic TV
MA - Monoscopic TV with Perceptive Aids
S - Stereoscopic TV
SA - Stereoscopic TV with Perceptive Aids

TEST DESCRIPTION

Roadway Tests

The roadway tests were conducted on the course previously described and shown in Figure 3-1. Each test was started with the vehicle centered and properly aligned in the roadway. The operators were instructed to maneuver

the vehicle along the test course with the following objectives in order of importance:

- To cover the course without having any of the ETM tires contact or cross over the boundary markers
- To complete the task in the shortest time possible
- To complete the test with as few commands as possible

A total of 25 tests identified as R-001 through R-025 were conducted; 19 of these were full course runs, while the balance covered less than the full 29 zones. Run 1 (R-001) covered zones 1 through 12, R-002 covered zones 11 through 29, R-010 covered zones 4 through 29, R-016 covered zones 1 through 27, R-017 covered zones 1 through 28, and R-023 covered zones 1 through 22. In general, the short runs were terminated early because of battery rundown. Run R-016 was excluded from most of the test analysis because of the obvious lack of confidence and the nervousness displayed by the operator while maneuvering the vehicle. This particular operator was dropped from further use after this run, which was his first. Of the 25 runs, 10 were conducted by driving the course in the opposite direction, i.e., from higher numbered zones to lower numbered zones. This was done in an effort to reduce the effects of the operator's familiarity with the track, but was probably not necessary, since a particular turn presented a different problem each time as a function of vehicle orientation at the approach.

During a test the operator was provided with the vehicle TV picture and, when the configuration allowed, steering aids. Each command issued to the vehicle was verbally stated by the operator and recorded along with the zone being negotiated and the time. The video signal to the operator's TV monitor was removed any time the vehicle was in motion or when the camera was being panned. A field observer followed behind the vehicle and recorded any errors as they occurred. The data recorded included the location of the error and the tire(s) involved. Errors of making contact with the roadway edge and errors of actually exceeding the boundary with the full tire(s) were separately identified.

Four system configurations were used during roadway testing: monoscopic television, monoscopic television with steering aids in the GSE, stereo television, and stereo television with steering aids. Each of the three operators made at least one run with each configuration.

The course itself was originally constructed using gypsum to mark the edges. The white marking was very clear on cloudy days, but tended to wash out in the TV system under certain bright sun angles. After rain permanently washed out the gypsum, the course was rebuilt using small sticks placed in the ground every 9 to 12 inches. These sticks, which extended about four inches above the ground, provided a clear picture of the roadway edge to the operator under all lighting conditions. Figure 3-8 is a photograph of the ETM during the roadway test phase.

Tank Trap Tests

The tank trap tests were started with the vehicle in an open area at one end of the field. The operator was instructed to survey the course, select the best path visible through the field and then to maneuver the vehicle along this path, modified as necessary, to the other end of the field.

Prior to the start of a test, the individual obstacles were arranged to provide one or two paths which could be traversed without climbing obstacles or hanging up a compartment. The course was then swept to remove tire tracks and footprints. The basic operating plan was similar to that employed during the roadway test phase, namely: the operator was instructed to traverse the field without errors, which were defined as hanging up the vehicle or climbing an obstacle, to accomplish this task as quickly as possible and to issue a minimum number of commands; the operator's TV picture was removed during vehicle and camera motion; all commands issued by the operator were recorded in chronological order; and the vehicle progress through the course was recorded by a field observer. Figure 3-9 shows the ETM in the tank trap field.

The original premise that the course could be limited to one or two traversable paths was a theory which was proven erroneous during each test. Any path selected by the operator as being negotiable could be traversed by the vehicle, due to the inherent mobility of the ETM, even through, through control errors, this meant climbing obstacles. Each of three operators drove the vehicle through the tank trap field six times for a total of eighteen tests. The vehicle television configuration for all of the tests was stereoscopic, while the perceptive aids for nine of the runs consisted of steering aids, and for the other nine runs consisted of both steering and measurement aids.

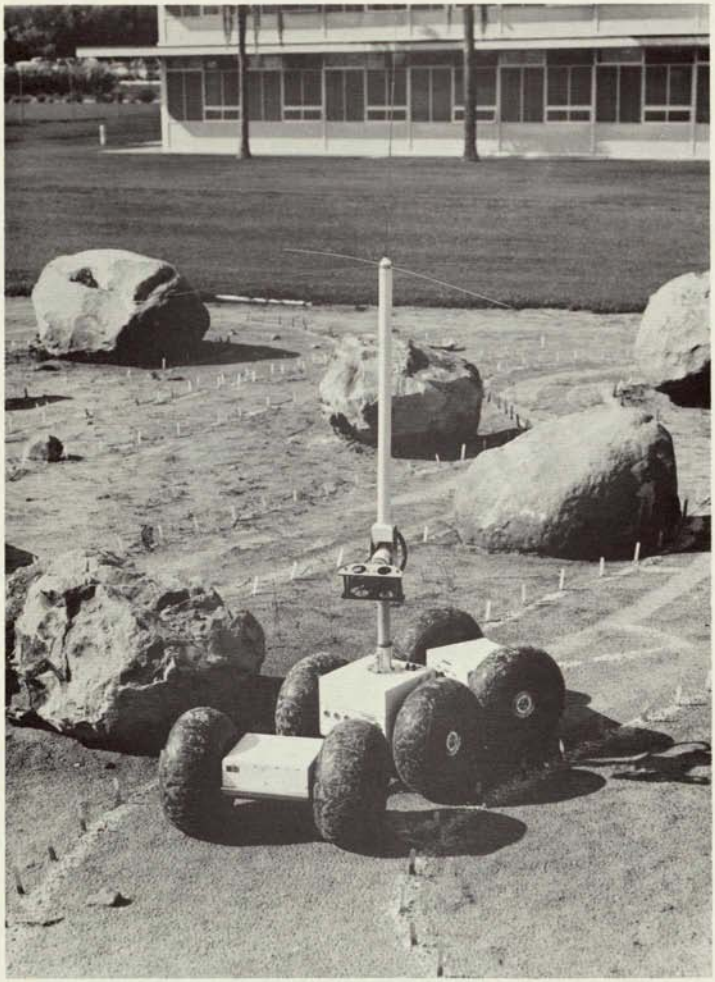


Figure 3-8. ETM During Roadway Test - Stereo TV Configuration

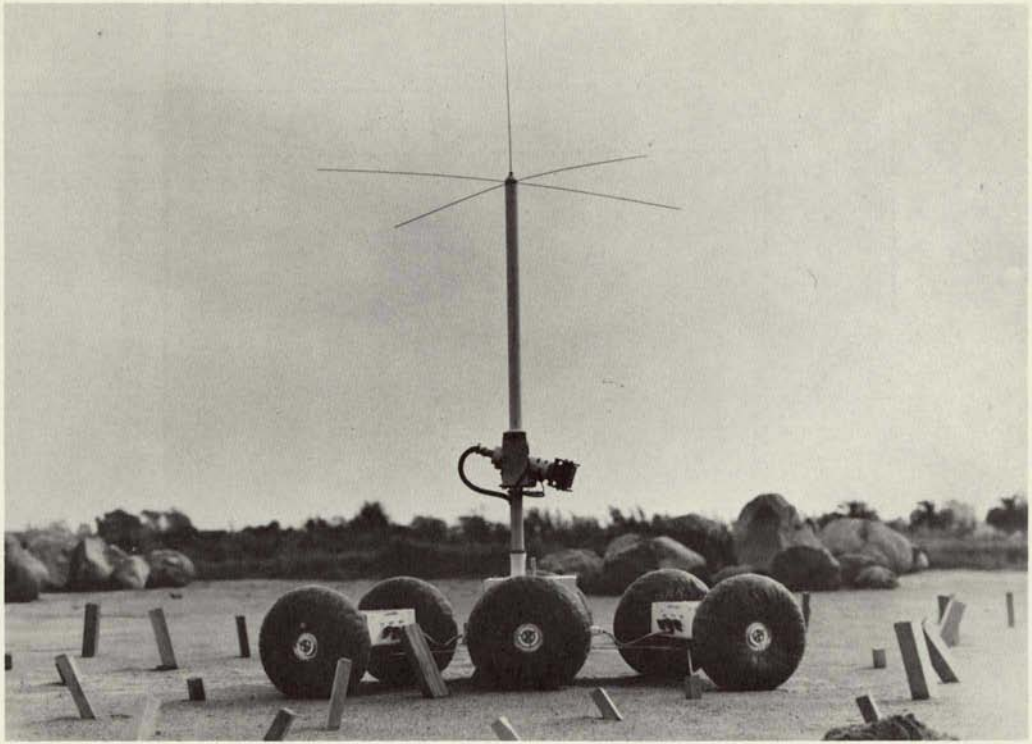


Figure 3-9. ETM Operating in the Tank Trap Field

General Lunarium Tests

The general lunarium tests were essentially open-field tests which presented a more realistic operating problem to the controller for long term maneuvering. During these tests the operator was given more freedom in selecting paths and could extend his field of interest up to four to six steps in front of the vehicle while traversing open ground. Major control problems were introduced by running the courses over slopes, crevices, and step obstacles, around rocks, and through the tank trap field.

These tests were organized along the lines of the SLRV control philosophy previously described. While the available equipment basically limited the functional aspects of the control loop to the Vehicle Controller Section, the other three sections were included in a reduced scope, or at least identified as having performed a function.

EXPERIMENT CONTROL - Being a long term navigation function, experiment control was included only insofar as having identified an intermediate objective (IO) for the Path Planning Section. The IO for each test was the finishing point.

PATH PLANNER - Most of the path planning function was performed as a pre-test activity. The desired path plan from the start to the finish of the course was derived, and a series of short range objectives (SRO's) were identified. Arrowheads were then placed in the lunarium at the SRO's to provide the vehicle controller with visual objectives. This means of marking SRO's was used because of GSE constraints, but worked quite successfully. From 11 to 14 SRO's were used to interconnect each course, as previously shown in Figure 3-3. Supplementary heading data to the next SRO were verbally provided to the operator when the arrow was outside the camera field of view. As an orientation aid, a plan view of the terrain encompassed by the vehicle camera was generated in real time along with the vehicle path. This plan view was made by tracing over an aerial photograph of the lunarium. A typical plan view, so generated, is shown in Figure 3-10.

VEHICLE CONTROLLER - The Vehicle Controller function was carried out by the operator who was responsible for maneuvering the vehicle safely from one SRO to the next until the IO was attained. The controller determined and issued all vehicle commands based upon his TV presentation.

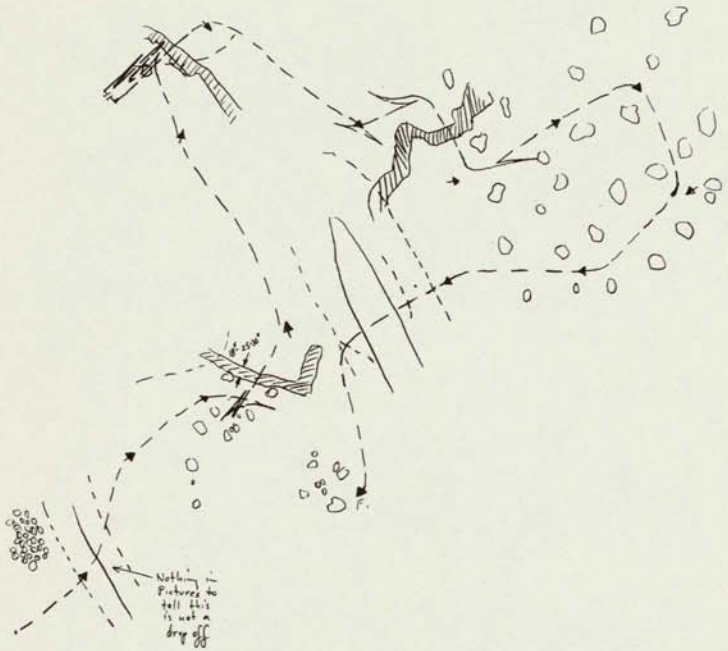


Figure 3-10. Typical Plan View - General Lunarium Testing

MOBILITY CHECKOUT - The mobility checkout function existed only in terms of verbal instructions by the test personnel and the presence of a field observer. In cases where the controller announced one command but, in fact, issued another, he was told of this error. As far as sending commands which could have damaged the vehicle is concerned, none were issued and the field observer was present to stop the vehicle.

The basic operating plan for the general lunarium tests in terms of instructions to the operator, data recordings, etc., was the same as during the other test phases. As far as traversing the course is concerned, the operator went directly from SRO to SRO and was required to cross obstacles in the path if they were within the limits of the vehicle mobility characteristics. The field observer recorded the vehicle path and the approach to crevice crossings. Figure 3-11 shows the ETM during a crevice crossing.

TEST DATA AND RESULTS

In examining a remote control loop of the SLRV type, one finds that many elements contribute to the error factor. These include not only the human element, but the vehicle and ground support equipment as well. A test program of the type conducted is, in general, not sufficiently complex to extract the effect of each element in a quantitative fashion. Therefore, the basic analysis of the vehicle test control loop was mainly qualitative and based upon the interpretations, observations, and evaluations of the test personnel and the operators. Other items such as configuration evaluation, command times, and vehicle rates, could be and were, treated in a quantitative way.

Camera/System Configuration

During the roadway tests, the operator's performance was measured in terms of his ability to keep all six vehicle tires within the course boundaries. At the end of each vehicle step, if one or more tires were in contact with a roadway edge, a minor error, or errors for more than one tire, was recorded along with which tire(s) was involved. If at the end of a vehicle step a tire(s) was completely outside the boundary, this was recorded as a major error(s) along with the tire(s) involved. Appendix A contains a tabular listing of the roadway test errors and commands by test and by zone. The error data was summarized by vehicle configuration and the results are shown in Table 3-5. Four groupings

Figure 3-11. Typical General Lunarium Crevice Crossing

TABLE 3-5.

ROADWAY TESTING - ERROR SUMMARY

Configuration	Error Rate (Errors/1000 ft)			
	Major Front	Major	Minor Front	Minor
Monoscopic No Aids	5.1	15.3	25.3	100.7
Stereoscopic No Aids	3.1	9.9	38.6	68.2
Monoscopic Aids	0.9	4.4	15.5	56.2
Stereoscopic Aids	0.5	1.5	15.0	58.9

of errors expressed in errors per 1000 feet of travel are included in the table: (1) major errors involving a front tire, (2) all major errors, (3) minor errors involving a front tire, and (4) all minor errors. The front tire errors are shown separately because the operator based his decisions upon the location of the front compartment on the roadway and where it would go for certain commands and thus provide the best measure of the control loop. The error rates indicated in the table show the value of perceptive aids quite well. Improvements in performance by introducing the steering aids were between 5 and 6 to 1 in terms of major errors. In addition, the error rates when using aids were very small; in the order of one major front tire error per two test runs for monoscopic TV, and one major front tire error per four test runs for stereoscopic TV.

In comparing the monoscopic and stereoscopic configurations, one finds only small differences in the error rates. The minor error rates were almost identical while the stereoscopic configuration showed slightly better performance with respect to major errors in spite of the narrower field of view. The primary advantage of the stereo system was the depth relationships between the vehicle tires and the roadway which the operator could extract from his TV image. One can conclude from the resultant error rates, and the command and vehicle rates which are presented in the following section, that the SLRV

can be maneuvered on the moon with monoscopic TV or stereoscopic TV with approximately equal proficiency, provided that:

- The area being traversed has been certified as negotiable with respect to the vehicle mobility
- Some form of stereo presentation is available to make this certification and to perform accurate measurements when an obstacle must be crossed whose size approaches the maximum traversing capability of the vehicle
- The operators are highly proficient in photo interpretation
- Complete vehicle angular information is available to the operator.

The need for some form of stereoscopic presentation is shown pictorially in Figures 3-12 through 3-16. These figures were derived from photographs of a TV monitor displaying the ETM split screen stereo image. Figure 3-12, when viewed monoscopically, shows only a slight, if any, depression in the terrain in front of the vehicle. This "depression" is, in fact, a crevice approximately 30 inches wide which is quite apparent when the picture is viewed stereoscopically. Figure 3-13 shows the same crevice when viewed from a few feet away and demonstrates the advantages of cast shadows in assessing terrain monoscopically. The same crevice viewed from the other side or into the sun is shown in Figure 3-14. Figures 3-15 and 3-16 show terrain which appears extremely hazardous monoscopically but which is, in fact, well within the safe mobility limits of the vehicle. These pictures show that monoscopic pictures can be very misleading by presenting a picture of safe terrain which is, in fact, hazardous; and by presenting a picture of hazardous terrain which is, in fact, safe. Thus, while driving monoscopically appears both feasible and practical, stereo certification of terrain is necessary. Maneuvering with only monoscopic presentations would be either impossible or extremely slow.

Vehicle and Command Rates

During the vehicle test program, the operators issued over 36,000 commands while maneuvering the vehicle along almost 3-1/2 miles of test course. The quantity of time history data obtained enabled a compilation of command rates and vehicle rates which can be used as a basis for estimating operational rates. The information presented in Tables 3-6, 3-7, 3-8, and 3-9 is a summary of

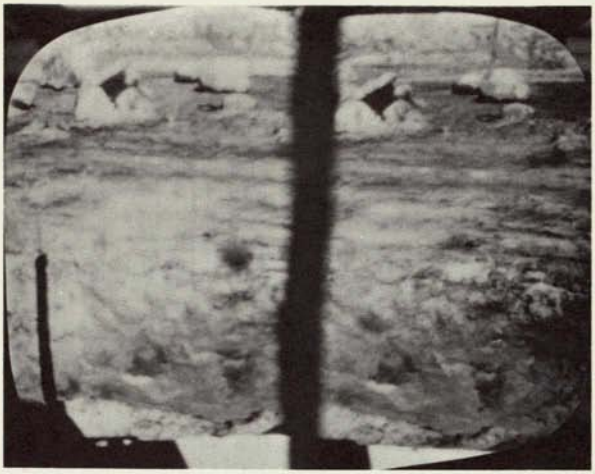


Figure 3-12. ETM Stereo TV Picture of 30" Crevice With The Sun Behind The Vehicle - Viewed From The Crevice Edge

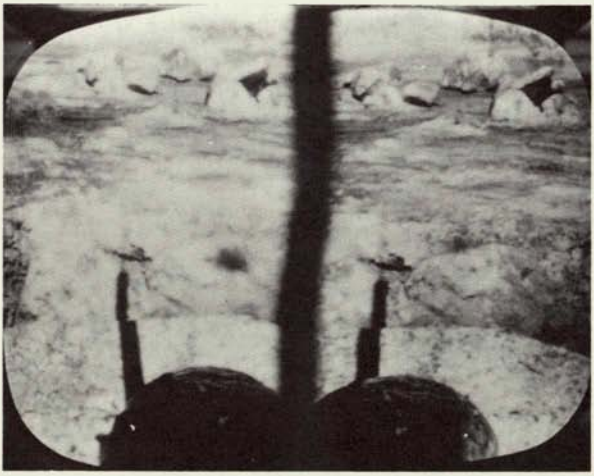


Figure 3-13. ETM Stereo TV Picture Of Same Crevice As In Figure 3-12- Viewed One Step Back Showing Shadow Clues

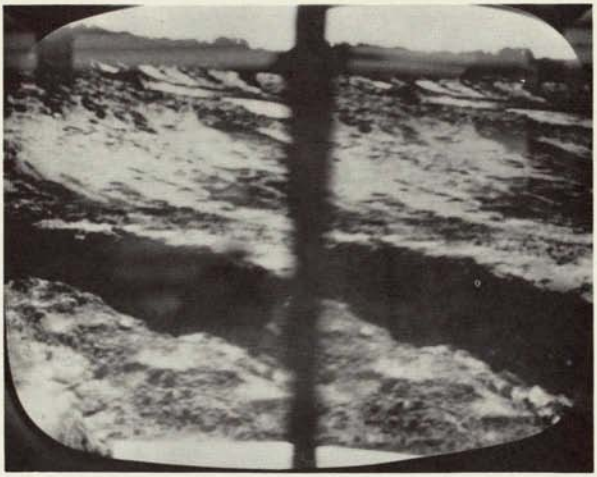


Figure 3-14. ETM Stereo TV Picture Of Crevice Of Figure 3-12 - Viewed Toward The Sun

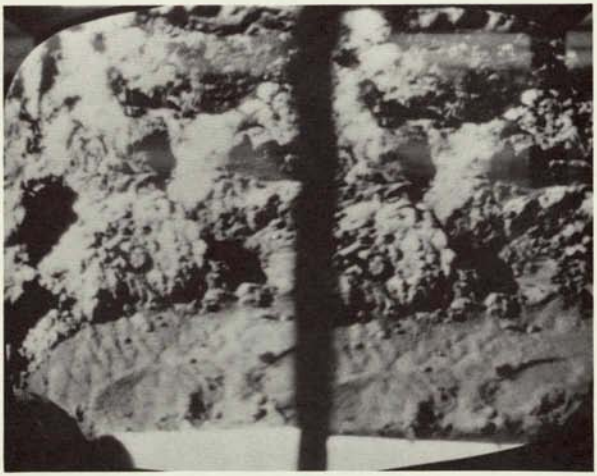


Figure 3-15. ETM Stereo TV Picture Of Terrain Easily Traversed By ETM

Figure 3-16. ETM Stereo TV Picture Of Traversable Terrain

TABLE 3-6.

ROADWAY TEST DATA SUMMARIES

		Vehicle Rate, MPM	Vehicle Rate, FPM	Command Rate, CPM	Total Commands	Steering Commands	Motion Commands	Camera Commands	Total Vehicle Commands	Picture Commands (GSE)	Test Duration (Min)	Meters Traveled	Feet Traveled
Test R-001,	As run	1.87	6.16	16.11	775	183	145	181	509	266	48	90.2	296
Mono, no aids	Projected	1.27	4.16	9.23	656	124	145	121	390	266	71	90.2	296
Test R-002,	As run	2.70	8.85	16.97	577	138	127	114	377	200	34	91.8	301
Mono, no aids	Projected	1.80	5.90	9.70	495	95	127	73	295	200	51	91.8	301
Test R-003,	As run	2.77	9.09	17 26	1105	258	258	202	718	387	64	177.5	582
Mono, no aids	Projected	1.83	6.00	9.92	963	189	258	129	576	387	97	177.5	582
Test R-004,	As run	3.70	12.12	20.4	962	207	285	107	599	363	48	177.5	582
Mono, no aids	Projected	2.19	7.18	11.17	905	179	285	78	542	363	81	177.5	582
Test R-010,	As run	2.63	8.62	18.88	1020	264	215	195	674	346	54	142.1	466
Mono, no aids	Projected	1.67	5.48	10.23	870	196	215	131	524	346	85	142.1	466
Test R-020,	As run	3.94	12.93	19.97	899	235	290	48	573	326	45	177.5	582
Mono, no aids	Projected	2.23	7.65	11.52	876	224	290	36	550	326	76	177.5	582
Avg rates,	As run	2.91	9.58	18.21									
Mono, no aids	Projected	1.85	6.09	10.33									

TABLE 3-6.

ROADWAY TEST DATA SUMMARIES (CONT)

		Vehicle Rate, MPM	Vehicle Rate, FPM	Command Rate, CPM	Total Commands	Steering Commands	Motion Commands	Camera Commands	Total Vehicle Commands	Picture Commands (GSE)	Test Duration (Min)	Meters Traveled	Feet Traveled
Test R-005,	As run	3.11	10.21	14.89	849	218	270	50	538	311	57	177.5	582
Mono, aids	Projected	2.04	6.68	9.52	829	207	270	41	518	311	87	177.5	582
Test R-006,	As run	3.86	12.65	17.82	820	217	273	31	521	299	46	177.5	582
Mono, aids	Projected	2.37	7.76	10.80	810	212	273	26	511	299	75	177.5	582
Test R-007,	As run	3.94	12.93	17.51	788	165	277	39	481	307	45	177.5	582
Mono, aids	Projected	2.40	7 86	10.44	773	159	277	30	433	307	74	177.5	582
Test R-011,	As run	2.82	9.23	18.85	1188	291	344	118	753	435	63	177.5	582
Mono, aids	Projected	1.70	5 59	10.90	1134	264	344	91	699	435	104	177.5	582
Test R-017,	As run	2.38	7.81	13.47	957	230	297	75	602	355	71	169.2	555
Mono, aids	Projected	1 63	5.33	8.87	923	213	297	58	568	355	104	169.2	555
Test R-018,	As run	3.94	12.93	16.35	736	183	271	3	457	279	45	177.5	582
Mono, aids	Projected	2.46	8.08	10.19	734	182	271	2	455	279	72	177.5	582
Test R-019,	As run	4.22	13 85	18.19	764	186	285	4	475	289	42	177.5	582
Mono, aids	Projected	2.53	8.31	10.65	764	186	285	4	475	289	70	177 5	582
Avg rates,	As run	3.34	10.96	16.53									
Mono, aids	Projected	2.10	6 90	10.18									

TABLE 3-6.
ROADWAY TEST DATA SUMMARIES (CONT)

		Vehicle Rate, MPM	Vehicle Rate, FPM	Command Rate, CPM	Total Commands	Steering Commands	Motion Commands	Camera Commands	Total Vehicle Commands	Picture Commands (GSE)	Test Duration (Min)	Meters Traveled	Feet Traveled
Test R-008,	As run	3.55	11.64	18.84	942	220	274	101	595	347	50	177.5	582
Stereo, no aids	Projected	2.24	7.36	10.55	834	192	274	47	513	321	79	177.5	582
Test R-009,	As run	3.70	12.12	18.68	897	197	277	84	558	339	48	177.5	582
Stereo, no aids	Projected	2.33	7.65	10.46	795	175	277	33	485	310	76	177.5	582
Test R-015,	As run	4.03	13.22	23.77	1046	270	276	136	682	364	44	177.5	582
Stereo, no aids	Projected	2.53	8.31	12.15	851	224	276	37	538	313	70	177 5	582
Test R-023,	As run	5.71	18.72	26.56	664	154	230	31	415	249	25	142.7	468
Stereo, no aids	Projected	2.97	9.75	12.89	619	143	230	8	381	238	48	142.7	468
Avg rates	As run	4.03	13 25	21.25									
Stereo, no aids	Projected	2.46	8.10	11.35									

Test R-012,	As run	3.01	9.86	21.81	1287	293	291	232	816	471	59	177 5	582
Stereo, aids	Projected	2.16	7.09	11 67	957	245	291	65	601	356	82	177.5	582
Test R-013,	As run	3.11	10 21	20.50	1169	255	335	139	729	440	57	177.5	582
Stereo, aids	Projected	2.02	6.61	11 13	980	224	335	43	602	378	88	177 5	582
Test R-014,	As run	2 43	7.97	12.26	895	213	262	89	564	331	73	177.5	582
Stereo, aids	Projected	1.81	5.93	7 84	769	195	262	25	482	287	98	177 5	582
Test R-021,	As run	3.22	10.58	17.90	985	252	286	96	634	351	55	177 5	582
Stereo, aids	Projected	2.11	6.92	10.45	878	226	286	40	552	326	84	177.5	582
Test R-022,	As run	3.41	11.19	18.78	977	223	281	113	617	360	52	177 5	582
Stereo, aids	Projected	2 30	7.55	10.45	805	187	281	28	496	309	77	177 5	582
Test R-024,	As run	2 69	8.81	14 28	943	206	273	112	943	352	66	177 5	582
Stereo, aids	Projected	1.99	6.53	8.55	761	165	273	25	463	298	89	177 5	582
Test R-025,	As run	3.11	10.21	19.61	1118	250	302	157	1118	414	57	177 5	582
Stereo, aids	Projected	2.06	6.76	10.46	900	212	302	42	556	344	86	177 5	582
Avg rates,	As run	2.96	9.73	17.59									
Stereo, aids	Projected	2.05	6.74	10.01									

TABLE 3-7.

LUNARIUM TEST DATA SUMMARIES

		Vehicle Rate, MPM	Vehicle Rate, FPM	Command Rate, CPS	Total Commands	Steering Commands	Motion Commands	Camera Commands	Total Vehicle Commands	Picture Commands (GSE)	Test Duration	Meters Traveled	Feet Traveled
Test L-001,	As run	0.96	3.13	10.68	1249	208	215	409	832	417	117	113	367
Course 1	Projected	0.89	2.91	11.86	783	167	215	230	612	279	126	113	367
Test L-009,	As run	3.05	9.91	13.51	500	93	136	113	342	158	37	113	367
Course 1	Projected	2.75	8 95	6.16	327	76	136	34	246	103	41	113	367
Test L-010,	As run	3.22	10.48	16.09	563	116	160	102	378	563	35	113	367
Course 1	Projected	2.51	8.15	7.88	418	93	160	41	294	418	45	113	367
Course 1	As run	1.79	5 82	12 23									
Avg rates	Projected	1 59	5.19	7.20									
Test L-002,	As run	1.43	4 70	10.66	757	141	124	239	504	253	71	102	344
Course 2	Projected	1.29	4 22	6.30	498	124	124	145	392	180	79	102	344
Test L-011,	As run	3.18	10.43	14.50	464	91	123	106	320	144	32	102	344
Course 2	Projected	2.55	8.35	8.50	340	84	123	58	265	105	40	102	344
Test L-012,	As run	3.09	10.12	14.03	463	86	126	92	304	159	33	102	344
Course 2	Projected	2.61	8.56	8.56	334	76	126	35	237	117	39	102	344
Course 2	As run	2.25	7.58	12.38									
Avg rates	Projected	1.93	6.53	7.41									

TABLE 3-7.

LUNARIUM TEST DATA SUMMARIES (CONT)

		Vehicle Rate, MPM	Vehicle Rate, FPM	Command Rate, CPS	Total Commands	Steering Commands	Motion Commands	Camera Commands	Total Vehicle Commands	Picture Commands (GSE)	Test Duration	Meters Traveled	Feet Traveled
Test L-003,	As run	1.23	4.05	13.23	1244	243	200	385	828	416	94	116	381
Course 3	Projected	1.10	3.67	7.54	792	198	200	212	610	292	105	116	381
Test L-007,	As run	1.70	5.60	12 68	862	203	198	207	608	254	68	116	381
Course 3	Projected	1.52	5.01	8 25	578	171	198	70	439	171	76	116	381
Test L-008,	As run	1.75	5.77	12.85	848	168	205	184	557	291	66	116	381
Course 3	Projected	1 45	4 76	7 61	609	147	205	82	434	215	80	116	381
Course 3	As run	1.52	5.01	12.95									
Avg rates	Projected	1.33	4.37	7 58									

Test L-004,	As run	3.48	11 42	13 77	482	112	158	63	333	149	35	122	400
Course 4	Projected	2.59	8 51	8.44	397	102	158	36	296	131	47	122	400
Test L-005,	As run	4.20	13.79	12 31	357	90	125	62	277	80	29	122	400
Course 4	Projected	3 69	12 12	8 06	266	76	125	24	225	55	33	122	400
Test L-006,	As run	3 93	12 90	12.55	389	96	140	41	277	112	31	122	400
Course 4	Projected	3.05	10.00	8 20	328	87	140	19	246	98	40	122	400
Course 4	As run	3.85	12.63	12.92									
Avg rates	Projected	2.83	9.30	8.25									

Courses 1-4	As run	2.09	6 90	12.62
Avg'd	Projected	1 80	5.96	7.54

TABLE 3-8.

GENERAL LUNARIUM TESTS - DECISION TIME SUMMARY

Raw Data				
Oper	Commands (Number)	Time (Minutes)	Command Rate (Comm/Min)	Vehicle Rate (Meters/Min)
G	3732	317	11.77	1.42
M	2183	166	13.15	2.72
W	2263	165	13.71	2.74

Corrected Data				
Oper	Commands (Number)	Time (Minutes)	Command Rate (Comm/Min)	Vehicle Rate (Meters/Min)
G	2470	357	6.91	1.26
M	1511	190	7.95	2.38
W	1689	204	8.27	2.22

TABLE 3-9.

GENERAL LUNARIUM TESTS - DECISION TIMES COURSE #4

Raw Data				
Oper	Commands (Number)	Time (Minutes)	Command Rate (Comm/Min)	Vehicle Rate (Meters/Min)
G	482	35	13.77	3.48
M	357	29	12.31	4.20
W	389	31	12.54	3.93

Corrected Data				
Oper	Commands (Number)	Time (Minutes)	Command Rate (Comm/Min)	Vehicle Rate (Meters/Min)
G	397	47	8.44	2.59
M	266	33	8.06	3.69
W	328	40	8.20	3.05

the data contained in Appendix A. The raw data reflects the tests as run where the command total includes all steering, pan, motion, enter pan, and enter steer commands and picture requests. The time data reflects the actual elapsed time for the various tests. The corrected (projected) data was modified for a lunar operation in the following areas:

COMMANDS - All enter pan and enter steer commands were deleted, since these two are ETM-peculiar. All pan commands issued to move the camera ±12° around center and the associated picture requests were deleted for stereo TV configuration tests on the assumption of a wider field of view.

TIME - The run time was modified by additions and deletions. A transmission time of 1.25 seconds was added for each corrected motion, steering, and pan command, and for receipt of each picture. Transmission time for a requested picture was not added, since picture commands would generally be time sequenced so as to be available when the vehicle completed the previous action. Three seconds were added for each picture request for the stereo configuration, and two seconds per picture request for the monoscopic configuration, to compensate for the time necessary to prepare and read out the vidicon(s). Subtraction from the run time was based upon one second per enter pan and enter steer command, and seven seconds per pan command for ±12° around center camera positions for stereo configuration tests (3 seconds to select and execute the command, and 4 seconds to interpret the picture).

The command rates experienced during roadway tests were between 16 and 21 commands per minute (ref. Table 3-6). These tests would produce higher command rates than normal since the vehicle path was completely defined, no obstacles were present in the roadway, and the vehicle motion was exclusively in 1/2-wheel revolution steps. The corrected rates for all configurations were approximately the same and in the order of 10 to 11 commands per minute. The vehicle rates were from 3 to 4 meters per minute, which was reduced to between 2 and 2-1/2 meters per minute in corrected form. The corrected command and vehicle rates for monoscopic and stereoscopic TV when using perceptive aids were, for all practical purposes, identical.

During the general lunarium tests, as shown in Table 3-7, the average command rates experienced were nearly the same for each course: between 12 and 13 per minute with the corrected rates being between 7 and 8 per minute. The average

projected command rate for course No. 4 (obstacle-free) was about 3/4 command per minute faster than for any other course. The as-run and corrected average vehicle rates, however, showed a wider spread between courses. The average as-run vehicle rates were from 1.5 to 3.85 meters per minute with the course No. 4 rate being over 1.5 meters per minute faster than any other course rate. Corrected average course rates were between 1.3 and 2.8 meters per minute. The overall averages for the general lunarium tests were 12.6 commands per minute as run and 7.5 commands per minute projected, and 2.1 meters per minute as run and 1.8 meters per minute corrected.

Looking at the same general lunarium test data, by operator, in Tables 3-8 and 3-9, one sees a large spread in the number of commands issued and the time required by the various operators. Operator G issued 80% more commands and took almost twice as long in traversing the four courses than did operator M. While the uncorrected rates for operators M and W were almost the same, operator M's actions proved somewhat more efficient when the data was corrected. Operator M had more driving experience and knowledge of the vehicle system than the other vehicle controllers. Operator G had some Control Model driving experience, but was basically unfamiliar with the ETM and the SLRV program in general. Therefore, the rates experienced by operator M are certainly more representative of what a trained operator would do during an operational mission than the rates of either operator G or W. Operator M had an average corrected vehicle rate of 2.4 meters per minute for the entire test phase and 3.7 meters per minute for course No. 4. Considering that formal training, more efficient, accurate, and flexible ground and vehicle equipment, and the presence of the Path Planning and Mobility Checkout Sections would increase his rates, and that maneuvering the vehicle on an unfamiliar moon, taking additional pictures for mapping and navigation, and taking soil bearing strength measurements would decrease his rates, one can conclude that average vehicle rates in the neighborhood of 180 meters per hour can be expected for the SLRV.

Control Loop

The three vehicle operators were in general agreement in their reactions toward the control problem. Driving the vehicle was either relatively easy and approached with confidence or quite difficult and approached with uncertainty, depending upon the terrain and test objectives. The simplest control problems

were encountered during general lunarium tests where the operator had some choice in his path, and where he could use the mobility of the vehicle. Even though this phase of testing included crevice, slope, and step obstacle crossings, the operators were able to bring the vehicle into proper crossing attitudes with confidence. Certain of the crevice crossing alignments were time consuming and required a good deal of maneuvering, but the operators were in full control of the vehicle and were confident in the actions they were taking. The most difficult control problems were presented by the tank trap tests where the operator, by the nature of his instructions, could not use the vehicle mobility as an aid in crossing the field. During these tests he had to avoid closely spaced obstacles and, in doing so, attempt to remember the locations of obstacles no longer in his field of view. Had the objective of these tests been only to traverse the field without hanging up the ETM, the overall control task would have been considerably simplified. The above factors are mentioned because the evaluation of the control loop and its associated elements is based upon what can be described as open-field driving, and upon requirements to maneuver in highly adverse terrain.

The control elements encountered in vehicle tests which contribute to control errors are as follows.

VEHICLE CHARACTERISTICS - This includes not only the basic mobility of the vehicle but also the control available over motion and steering. Another factor is the way in which the vehicle moves in response to commands, that is, the paths taken by the center and rear compartments with respect to the front compartment.

PICTURE QUALITY - This element is defined as the accuracy to which the terrain viewed by the vehicle is presented to the operator. It includes such factors as linearity, noise, and parameters associated with detectability.

VIEWING CAPABILITY - This element is associated with the information available to the operator in terms of the terrain the vehicle is in, and the terrain into which the vehicle is going. Thus, this element not only includes field of view, but also usage of previous pictures.

PRECEPTION ACCURACIES - Perception accuracy is defined as the accuracy to which the operator can determine the location of objects in his TV image.

SLIP-SLIDE - This element refers to the deviation of the vehicle path from the intended path due to the vehicle slipping or sliding.

OPERATOR JUDGMENT - This element refers to the ability of the operator to select the proper sequence of commands necessary to accomplish a certain objective.

PRECISION OF THE OPERATING GROUND EQUIPMENT - This factor is basically associated with measurement aids and steering aids.

The contribution of these seven elements to the control accuracy, as seen during the vehicle tests, can be expected to be quite different from the contribution expected during the operational SLRV mission. The effects of these elements, and what can be done to minimize their contribution to the overall control error, is discussed below.

VEHICLE CHARACTERISTICS - The basic mobility factor of the vehicle will have a significant effect on the path taken from one objective to another; and, from this consideration, the more mobile the vehicle, the simpler the mission in terms of number of commands, distance traveled, and overall mission time. The vehicle characteristics which contribute to the control error, however, are those of step steering, step motion, and compartment orientations during turns. During each phase of the control tests, situations were encountered where shorter vehicle steps and/or smaller steering increments would have aided the driver in negotiating a turn or aligning the vehicle with respect to an obstacle. In attempting to achieve finer incremental control, the operators frequently issued stop commands giving something less than the 1/2-wheel revolution step. This method of obtaining orientations of the vehicle, not possible with full steps, proved quite successful. In the operational situation where the commands can be issued on an accurately spaced time basis, almost any vehicle orientation should be available with the incremental steering system. Thus, if the vehicle controller were provided with a display showing the resultant vehicle orientation for various steering angles and a selected motion time, the effects of step-steering should be minimized. Again considering the vehicle mobility, where small misalignments do not present a problem, step steering coupled with timed motion steps should become an insignificant element in the control error. The problems associated with the center and rear compartments not tracking the front compartment during turns only need be considered when operating in a tank trap

type environment. This can be compensated for by either assuming a wider vehicle or by having adequate viewing capability of the terrain around the vehicle to select steering and motion commands which do not result in the center or rear compartments becoming hung up or wedged upon an obstacle. (NOTE: No cases of hanging up or wedging obstacles occurred during the test program)

PICTURE QUALITY - The effect of picture quality is essentially that of presenting test personnel with an image which shows objects offset from their real locations. The basic factor involved here is the linearity of the television system which is covered in Section II of this report. For the TV system selected, this becomes a fixed error vs range function, and thus a known element.

VIEWING CAPABILITY - Viewing capability as it affects control falls into two categories: (1) the horizontal field of view presented by the TV camera, and (2) the ability to see the terrain immediately around the entire vehicle. The field of view is important in terms of the operator being able to assess the terrain into which he will maneuver the vehicle. This can be accomplished with almost any field of view by panning the camera over the area of interest and simultaneously displaying the resultant sequence of pictures. From the operator's standpoint, a field of view which in a single picture, encompasses the terrain three vehicle steps away for any steering angle would be desirable but, as pointed out, could be accomplished by a sequence of pictures. The field angle best suited for the SLRV must consider the requirements of all phases of the mission (mapping, navigation, and control) and the accuracies required for each. The aspect of viewing the terrain immediately around the entire vehicle is important for critical control situations where objects may become wedged in the vehicle. This is a minority situation and can probably be accomplished by using previous pictures. Being able to orient the vehicle within these previous pictures and knowing the vehicle characteristics, proper maneuvering commands can be issued. Overall, the viewing capability element should have only minor contributions to control error.

PERCEPTION ACCURACY - Perception accuracy which is discussed in detail in Section II will, in general, be a fixed parameter. Since the perception error is a function of range, it will become less important as the vehicle approaches an obstacle, and will be minimized just prior to an obstacle crossing.

SLIP-SLIDE OF VEHICLE - During the vehicle tests a certain amount of vehicle slide on side slopes and off of small rocks was observed, as was a small amount of slippage. The vehicle slide contributed slightly to the errors encountered during roadway tests, particularly when the vehicle was being driven horizontally across a slope. In relating the observed slide to a lunar operation, however, no harmful effects can be seen. Considering vehicle slip, there is some effect on path prediction, since the vehicle does not traverse the intended amount of terrain during the motion stop. Since, however, the individual commands are issued to move the vehicle only a few meters, the next sequence of commands will be based upon the updated TV information and, in general, vehicle slip will not even be recognized. During general lunarium tests the effects of slip and slide, if any, were not recognizable. This same lack of effect in the control loop can be expected during lunar operation.

OPERATOR JUDGMENT - As shown in the analysis of the various TV camera/system configurations during roadway testing, the operator judgment becomes a significant factor when full interpretation of resultant vehicle movements is left to the operator. When using perceptive steering aids, however, the operator need only select the steering and motion commands which best fit the situation based entirely upon these aids. Given an accurate set of steering aids and accurate measurement tools, the controller's function is basically that of acting as a logic element in selecting commands. A certain proficiency on the part of the operator is required during maneuvers necessary to orient the vehicle with respect to an obstacle to achieve the optimum angle of attack. This proficiency should result from an understanding of the vehicle and driving experience. Thus, with adequate training and suitable OGE, the operator judgment factor should be almost eliminated as a control error.

PRECISION OF OPERATING GROUND EQUIPMENT - The majority of the control accuracy will depend on how accurately the TV image is presented to the test personnel, and how precise the measurement and steering aids are over the range of interest. Highly accurate steering aids or tire tracks over a one to three step distance which are compensated for slope will produce highly accurate maneuvering results. Similarly, precision measurement tools which are usable for evaluating obstacles a few meters away from the vehicle will enable full utilization of the vehicle mobility. The entire area of ground support equipment precision is the one where the most gains in control accuracy will be accomplished.

The effects of the above elements on the control accuracy encountered during the test program could not be segregated due to the nature of the equipment and the scope of the study. However, in terms of roadway and general lunarium testing, the major contributions to the control error were in the ground support equipment, picture quality, and operator training. During general lunarium tests, the basic measure of control was the accuracy to which the operators aligned the vehicle at crevice crossings. None of the 21 crevice crossings resulted in any form of jeopardy to the vehicle. The angular approaches were, in general, perpendicular to the front edge of the crevice to within a few degrees and showed good control on the part of the operator. The vast majority of displacement errors encountered during roadway tests were in the nature of less than 4 inches. Where displacement errors exceeded 8 inches (tire outside the roadway), the cause was generally improper evaluation of the perceptive aids and/or terrain. In the operational case, such errors would not have occurred, due to the presence of the mobility checkout function. To attempt to place a number on the SLRV control margin for purposesof derivingthe effective safe mobility of the vehicle, is a difficult task and is at best, an estimate based on what was observed and what can be accomplished in operational equipment. The control over one vehicle step should certainly be within 2 inches displacement and 3 to 5° front compartment orientation.

OGE Concepts

The vehicle testing conducted as a part of the control study presented an opportunity to evaluate the existing conceptual approach to OGE functional requirements as outlined in Section I, "Control Philosophy." As previously stated, the Vehicle Controller portion of the control loop received a thorough investigation, while remaining portions of the loop were, for the most part, simulated. The following is a brief description of requirements now considered applicable to the mechanization of the Vehicle Controller's equipment.

Television Viewers

(a) High quality monitors to present viewing of sufficient accuracy for control purposes.

A minimum of three television viewers are required, these monitors are to provide viewing of the current SLRV down-look picture, last

up-look picture of SRO, and one providing a view of selected information, such as a recall picture or plan view.

(b) Perceptive aids for steering

Means should be provided for injecting any set of vehicle tire tracks into the current SLRV down-look picture. These aids should be fully synchronized with the vehicle television camera system and, if required, the vehicle steering attitude, so as to present correct viewing of the summation of picture and tire tracks for any camera or vehicle steering position. The correction for vehicle steering angle will have to be employed if the camera is not mounted so as to be independent of steering. These steering aids must be highly accurate for a distance of three vehicle steps, and must be corrected for vehicle/terrain slope differentials which would affect the intended path of the vehicle by a significant amount.

It is desirable to control the injection of these aids by the vehicle steering controls, the command(s) required to select an aid being identical to the commands which would cause the vehicle to follow the path indicated by the aid. Following the selection of a path, the stored commands would proceed to the vehicle if enabled by the Mobility Checkout station. A mechanization of this type would relieve the operator of having to determine his present camera angle, and steering and modifications necessary to cause the vehicle to follow the selected path.

A means should also be provided to inject a marker such as a point of light into each viewer, this point to be controlled both locally and from either the Path Planner or Mobility Checkout area viewers. This would enable discussion of a particular point of interest, such as an obstacle to avoid, a desirable or intended course, etc.

(c) Non-optical Displays

- Digital, current azimuth angular offset between center vehicle compartment and SRO.
- Digital, current distance in vehicle step increments to SRO.
- Digital, predicted azimuth angular offset between center compartment and SRO, prediction to be made on a basis of steering aid selection and number of vehicle steps entered prior to execution.

- Digital, predicted distance in vehicle step increments to SRO, prediction to be made on a basis of steering aid selection and number of vehicle steps entered prior to execution.
- Digital, current vehicle angular gradeability remaining, computed on a basis of current vehicle attitude and geometric capability minus a safety factor determined from lunar terrain composition.
- Digital, predicted vehicle angular gradeability remaining following execution of selected commands.
- Pictorial, plan view of vehicle and vehicle tire tracks for any steering angle and including tire tracks depicting the route by which the vehicle arrived at its current position; these tire tracks should be displayed for at least one vehicle length.
- Digital, camera azimuth, referenced to vehicle center compartment.
- Digital, current vehicle steering angle.
- Digital, predicted vehicle steering angle, based on steering aid selection.
- GO/NO GO, to provide notice that an intended maneuver will position the vehicle such that sun angle will not permit use of vehicle TV.
- GO/NO GO, to indicate an intended maneuver is prohibited due to a change in vehicle characteristics because of equipment failure, temperature instability, etc.

(d) Optical Displays

- Artificial horizon(s) displayed on the vehicle television monitors.
- GO/NO GO, a means of indicating a no go situation on the television monitors. This indication would appear when a significant out-of-tolerance condition arose, or any of the non-optical displays predicted an intended maneuver was undesirable.

(e) Film Library

A method should be provided to photograph the vehicle controller's down-look monitor. These photographs should be taken automatically each time a change of vehicle position occurs. This film document

should depict the vehicle controller's view of the terrain, selected perceptive aids, and artificial horizon(s). It may also be useful to include all optical and non-optical display data on this film record. It should also provide for selective filming of any monitor scene.

These film documents should be processed extremely rapidly and should be filed in a recall system which would permit very quick selection of any picture stored between SRO's.

Projection of these film documents should be in a manner which presents the information as it was originally viewed, i.e., size, contrast, etc.

APPENDIX A

TEST DATA

- Roadway Test Data
- Tank Trap Test Data
- General Lunarium Test Data

ROADWAY TEST DATA

ROADWAY TEST COMMAND-TIME HISTORY SUMMARY

Test No.	Oper.	Camera Pan						Steering						Motion					Time (min)	Major Fail			Minor Fail			Zones	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	60	0	41	47	31	2	59	1	44	24	54	1	0	137	1	7	0	48	2	0	0	10	9	1	1-12	M-NA
R-002	G	41	0	22	26	25	0	43	0	25	33	37	0	0	125	0	2	0	34	3	2	4	3	9	3	11-29	M-NA
R-003	G	73	1	37	42	49	0	69	1	57	61	69	1	1	253	1	3	0	64	4	4	3	25	29	16	1-29	M-NA
R-004	G	29	1	21	19	22	15	28	4	71	48	54	2	0	279	0	6	0	48	3	6	6	21	19	13	1-29	M-NA
R-005	G	9	1	10	9	20	1	11	2	67	64	71	3	0	260	2	8	0	57	1	2	1	11	24	12	1-29	M-A
R-006	G	5	0	12	6	8	0	5	0	83	54	72	3	3	261	3	6	0	46	0	2	1	15	20	15	1-29	M-A
R-007	G	9	0	8	7	15	0	7	8	43	45	62	1	0	275	0	2	0	45	0	1	4	13	13	37	1-29	M-A
R-008	G	28	0	14	19	40	0	28	0	67	55	67	3	0	272	0	2	0	50	1	0	2	32	13	35	1-29	S-NA
R-009	G	22	0	25	19	18	0	22	2	71	39	62	1	0	273	0	4	0	48	5	1	11	32	23	30	1-29	S-NA
R-010	M	64	7	37	47	40	0	53	4	68	59	57	8	0	210	0	5	0	54	1	2	2	8	15	5	4-29	M-NA
R-011	M	27	5	30	38	18	0	27	3	99	73	84	5	1	303	0	40	0	63	0	1	2	9	21	10	1-29	M-A
R-012	M	52	3	62	77	38	0	48	5	74	69	95	2	2	273	0	16	0	59	1	2	9	14	34	21	1-29	S-A
R-013	M	34	2	31	42	30	0	31	1	74	64	82	3	0	296	0	39	0	57	0	0	0	6	20	6	1-29	S-A
R-014	M	20	1	22	27	19	0	18	2	67	54	70	2	1	257	0	4	0	73	0	0	0	5	8	6	1-29	S-A
R-015	M	48	0	23	29	36	0	45	11	64	47	98	5	0	264	0	12	0	44	0	0	0	11	11	17	1-29	S-NA
R-016	B	16	2	21	21	42	0	16	0	84	60	99	3	1	247	0	13	0	147	3	1	0	12	8	14	1-27	M-A
R-017	W	17	2	18	23	15	0	17	2	72	58	79	2	0	287	0	10	0	71	0	0	0	3	1	0	1-28	M-A
R-018	W	1	0	1	1	0	0	1	1	82	46	53	0	0	267	0	4	0	45	0	0	1	5	3	4	1-29	M-A
R-019	M	0	0	2	1	0	1	0	6	68	43	67	2	0	277	0	8	0	42	0	0	0	3	0	5	1-29	M-A
R-020	W	12	0	12	15	9	0	11	5	79	51	87	2	0	279	0	11	0	45	0	0	0	7	0	3	1-29	M-NA
R-021	W	31	0	20	23	22	0	26	3	85	53	82	3	0	275	7	4	0	55	0	0	0	9	4	8	1-29	S-A
R-022	W	34	2	24	28	25	0	36	4	72	47	62	2	0	276	0	5	0	52	0	0	2	10	8	15	1-29	S-A
R-023	W	12	2	2	8	7	0	11	9	57	33	43	1	0	226	0	4	0	25	1	0	0	13	11	1	1-22	S-NA
R-024	G	33	2	24	33	20	0	41	11	50	32	71	1	3	267	0	6	0	66	1	0	0	11	16	9	1-29	S-A
R-025	G	40	1	41	42	28	0	38	11	62	64	74	1	0	282	6	14	0	57	0	0	0	6	8	15	1-29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 1 TRACK WIDTH 4.5' LENGTH 21' RADIUS 8'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	4	0	4	4	0	0	4	0	2	1	1	0	0	9	1	1	0	4:30	0	0	0	2	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	--	-	-	-	-	-	-	11	M-NA
R-003	G	2	0	1	1	0	0	2	0	8	1	1	0	0	10	0	0	0	3:00	0	0	0	0	0	0	1	M-NA
R-004	G	1	0	0	1	2	0	1	1	0	2	3	0	0	10	0	0	0	1:30	1	0	0	2	2	1	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	7	3	0	0	0	14	0	0	0	2:30	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	1	2	4	0	0	10	0	0	0	1:00	0	0	0	1	0	0	29	M-A
R-007	G	1	0	0	1	3	0	1	0	2	2	5	0	0	11	0	0	0	1:00	0	0	0	2	0	2	29	M-A
R-008	G	1	0	3	1	0	0	1	0	4	1	1	0	0	11	0	0	0	3:00	0	0	0	0	0	1	1	S-NA
R-009	G	1	0	0	1	0	0	1	0	3	2	5	0	0	13	0	1	0	1:30	0	0	0	1	1	0	29	S-NA
R-010	M	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	--	-	-	-	-	-	-	29	M-NA
R-011	M	1	0	1	2	1	0	0	0	2	1	4	0	0	12	0	1	0	2:00	0	0	0	0	0	0	29	M-A
R-012	M	1	0	1	0	0	0	1	0	6	0	2	0	0	12	0	0	0	1:30	0	0	0	0	1	0	1	S-A
R-013	M	5	0	9	5	1	0	3	0	5	1	2	0	0	13	0	7	0	5:30	0	0	0	2	3	2	1	S-A
R-014	M	2	0	2	1	0	0	1	0	0	2	0	0	1	3	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	0	0	5	0	2	0	0	11	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-016	B	1	0	1	1	0	0	1	0	8	0	7	0	0	13	0	0	0	13:30	0	0	0	0	0	0	1	M-A
R-017	W	2	0	3	2	0	0	2	0	6	1	1	0	0	16	0	0	0	5:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	2	2	3	0	0	11	0	0	0	2:00	0	0	0	1	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	4	0	2	0	0	14	0	1	0	2:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	4	2	6	0	0	12	0	1	0	2:00	0	0	0	0	0	0	29	M-NA
R-021	W	3	0	4	1	2	0	2	0	4	1	2	0	0	14	0	0	0	2:00	0	0	0	2	2	0	1	S-A
R-022	W	0	0	0	0	0	0	0	0	2	3	5	0	0	12	0	0	0	1:00	0	0	0	0	0	1	29	S-A
R-023	W	2	0	2	0	0	0	2	0	4	0	2	0	0	10	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	3	0	2	0	0	12	0	0	0	2:00	0	0	0	0	3	0	1	S-A
R-025	G	1	0	0	2	1	0	1	1	1	3	5	0	0	11	1	0	0	3:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 2 TRACK WIDTH 4.5' LENGTH 58' RADIUS 14'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	15	0	2	6	10	0	14	0	8	1	14	0	0	23	0	1	0	7:00	0	0	0	0	0	0	1	M-NA
R-002	G	--	-	-	-	--	-	--	-	--	-	--	-	-	--	-	-	-	--	-	-	-	-	-	-	11	M-NA
R-003	G	8	0	0	5	6	0	9	0	3	8	11	0	0	23	0	0	0	7:00	0	0	0	3	2	1	1	M-NA
R-004	G	4	0	4	3	0	0	4	2	13	3	6	0	0	26	0	0	0	4:30	0	0	0	2	2	3	29	M-NA
R-005	G	2	0	1	1	2	0	2	0	3	2	6	0	0	21	0	0	0	4:30	0	0	0	0	0	1	1	M-A
R-006	G	1	0	2	1	0	0	1	0	12	5	3	0	0	30	0	0	0	4:00	0	0	0	0	0	1	29	M-A
R-007	G	2	0	5	0	1	0	2	0	9	3	4	0	0	26	0	0	0	5:00	0	0	0	0	0	0	29	M-A
R-008	G	2	0	0	2	5	0	2	0	2	5	6	0	0	23	0	0	0	4:00	0	0	0	0	0	0	1	S-NA
R-009	G	2	0	5	2	2	0	2	1	10	4	6	0	0	28	0	0	0	5:30	0	0	0	0	0	0	29	S-NA
R-010	M	--	-	-	-	--	-	--	-	--	-	--	-	-	--	-	-	-	--	-	-	-	-	-	-	29	M-NA
R-011	M	4	0	5	6	0	0	4	0	11	2	8	0	0	29	0	4	0	5:30	0	0	0	0	0	1	29	M-A
R-012	M	6	0	5	9	5	0	6	0	2	5	12	0	0	27	0	0	0	4.30	0	0	0	0	1	1	1	S-A
R-013	M	9	0	4	9	8	0	8	0	3	4	10	0	0	29	0	6	0	7:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	1	1	3	0	0	10	0	0	0	8:00	0	0	0	0	0	0	29	S-A
R-015	M	6	0	2	7	6	0	6	0	7	3	11	0	0	26	0	0	0	4:00	0	0	0	0	0	0	1	S-NA
R-016	B	1	0	1	2	2	0	1	0	2	13	19	0	0	20	0	1	0	22:30	0	0	0	3	1	2	1	M-A
R-017	W	3	0	3	6	3	0	3	0	3	3	8	0	0	24	0	0	0	8:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	12	6	3	0	0	25	0	0	0	3:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	4	3	7	0	0	24	0	0	0	4:00	0	0	0	0	0	0	1	M-A
R-020	W	2	0	1	1	0	0	2	0	9	2	7	0	0	26	0	1	0	3:30	0	0	0	0	0	0	29	M-NA
R-021	W	6	0	1	5	4	0	6	0	3	5	13	0	0	25	0	2	0	9:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	1	0	6	1	3	0	0	27	0	1	0	4:00	0	0	0	1	0	0	29	S-A
R-023	W	3	0	0	2	1	0	2	0	2	2	3	0	0	25	0	0	0	2:30	0	0	0	3	4	0	1	S-NA
R-024	G	6	0	1	4	4	0	7	0	0	2	8	0	0	23	0	0	0	6:00	0	0	0	1	2	1	1	S-A
R-025	G	6	0	5	3	0	0	6	0	5	3	6	0	0	28	0	2	0	5:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 3 TRACK WIDTH 3.5' LENGTH 37' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	9	0	14	8	7	0	9	0	5	3	6	0	0	19	0	1	0	6:30	0	0	0	2	2	1	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	5	0	5	2	3	0	4	0	5	5	5	1	0	18	0	0	0	3:30	1	0	0	3	3	2	1	M-NA
R-004	G	1	0	0	1	3	0	1	0	6	2	4	1	0	17	0	3	0	3:30	0	1	0	4	2	3	29	M-NA
R-005	G	1	0	1	2	3	1	1	0	4	3	5	2	0	17	0	1	0	5:00	0	0	0	1	5	3	1	M-A
R-006	G	0	0	0	0	0	0	0	0	8	3	6	0	0	12	0	2	0	3.00	0	1	1	1	2	1	29	M-A
R-007	G	0	0	0	0	0	0	0	0	10	3	6	0	0	16	0	0	0	2:30	0	0	0	1	2	3	29	M-A
R-008	G	1	0	0	1	3	0	1	0	7	3	8	1	0	17	0	0	0	3:00	0	0	0	5	2	5	1	S-NA
R-009	G	3	0	4	2	0	0	3	0	9	3	2	1	0	16	0	0	0	2:30	1	0	0	2	1	4	29	S-NA
R-010	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	29	M-NA
R-011	M	3	0	4	7	4	0	3	1	3	3	5	1	0	18	0	3	0	4:30	0	0	0	2	6	2	29	M-A
R-012	M	2	0	3	4	2	0	2	0	4	4	5	0	0	14	0	0	0	4:30	0	0	0	2	7	4	1	S-A
R-013	M	1	0	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	3:30	0	0	0	0	2	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	7	3	4	0	0	25	0	0	0	2:30	0	0	0	0	1	0	29	S-A
R-015	M	7	0	1	1	5	0	5	1	6	6	10	2	0	27	0	1	0	3:30	0	0	0	0	2	4	1	S-NA
R-016	B	1	0	2	1	0	0	1	0	7	2	5	0	0	10	0	2	0	21:30	0	0	0	2	4	4	1	M-A
R-017	W	3	0	3	5	4	0	3	0	10	3	10	0	0	24	0	1	0	4:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	1	9	3	2	0	0	18	0	0	0	3:00	0	0	0	1	2	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	6	4	10	0	0	18	0	1	0	3:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	1	3	0	1	1	11	5	4	1	0	16	0	2	0	4:00	0	0	0	0	0	0	29	M-NA
R-021	W	2	0	1	0	3	0	2	0	7	3	6	1	0	17	0	1	0	6:00	0	0	0	5	3	1	1	S-A
R-022	W	3	0	1	2	1	0	3	0	4	3	7	0	0	14	0	0	0	3:00	0	0	0	5	5	1	29	S-A
R-023	W	4	2	0	3	2	0	4	1	7	3	6	0	0	19	0	1	0	3:30	0	0	0	4	2	0	1	S-NA
R-024	G	0	0	2	4	0	1	2	3	1	2	3	1	0	16	0	1	0	4:30	0	0	0	1	2	1	1	S-A
R-025	G	1	0	4	3	2	0	3	0	11	3	5	0	0	14	2	2	0	3:30	0	0	0	0	1	2	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 4 TRACK WIDTH 3.5' - 4.5' LENGTH 21' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	4	0	7	3	0	0	4	0	6	3	2	0	0	11	0	0	0	3:00	0	0	0	0	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	2	0	2	1	0	0	2	0	4	1	0	0	0	8	0	0	0	2:00	0	2	1	4	3	1	1	M-NA
R-004	G	1	0	0	1	2	0	1	0	0	4	5	1	0	9	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	1	3	2	3	0	0	9	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	2	1	4	1	0	9	0	1	0	1:00	0	0	0	2	3	1	29	M-A
R-007	G	2	0	1	1	4	0	1	0	3	0	2	0	0	8	0	0	0	2:00	0	0	0	0	0	3	29	M-A
R-008	G	0	0	0	0	0	0	0	0	2	1	1	0	0	12	0	0	0	1:30	0	0	0	2	1	4	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	2	1	4	0	0	9	0	0	0	2:00	0	0	0	4	0	5	29	S-NA
R-010	M	3	0	1	4	6	0	3	0	0	2	6	0	0	8	0	1	0	2:30	0	0	0	0	0	2	29	M-NA
R-011	M	2	0	3	2	3	0	3	0	0	2	5	1	0	10	0	2	0	2:30	0	0	0	0	0	0	29	M-A
R-012	M	1	0	2	2	0	0	1	1	3	1	0	0	0	7	0	0	0	2:00	0	0	0	1	1	0	1	S-A
R-013	M	2	0	4	3	0	0	2	0	6	3	5	1	0	19	0	2	0	1:30	0	0	0	0	0	0	1	S-A
R-014	M	1	0	3	1	0	0	1	2	4	4	6	1	0	15	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	3	0	0	2	3	0	4	0	1	4	6	0	0	15	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-016	B	2	0	8	2	1	0	1	0	6	1	2	0	0	8	0	4	0	14:00	0	0	0	0	0	0	1	M-A
R-017	W	3	1	3	2	2	0	3	2	4	1	5	0	0	9	0	3	0	7:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	6	2	3	0	0	9	0	1	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	1	8	1	3	0	0	12	0	1	0	2:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	1	0	0	0	0	0	3	2	5	1	0	11	0	1	0	1:30	0	0	0	0	0	4	29	M-NA
R-021	W	2	0	6	2	1	0	2	1	5	2	5	0	0	7	5	1	0	3:00	0	0	0	0	0	0	1	S-A
R-022	W	2	0	1	1	1	0	2	0	3	3	6	0	0	11	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	5	1	2	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	2	0	1	0	1	1	1	1	0	0	0	11	0	0	0	3:00	0	0	0	0	0	0	1	S-A
R-025	G	2	0	2	2	2	0	1	0	3	4	7	0	0	10	0	0	0	2:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 5 TRACK WIDTH 4.5' LENGTH 34' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	2	0	1	1	2	0	2	0	4	1	5	0	0	13	0	0	0	4:30	0	0	0	0	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	3	0	0	2	1	0	2	0	4	4	4	0	0	14	0	0	0	3:30	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	3	4	0	0	0	16	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	3	4	4	0	0	15	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	4	3	4	0	0	15	0	0	0	3:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	3	3	3	0	0	17	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-008	G	0	0	0	0	0	0	0	0	1	3	2	0	0	15	0	0	0	1:30	0	0	0	1	0	0	1	S-NA
R-009	G	1	0	3	1	2	0	1	0	2	2	1	0	0	15	0	0	0	2:30	0	0	0	0	0	0	29	S-NA
R-010	M	4	0	4	2	1	0	2	0	7	5	3	0	0	18	0	0	0	3:00	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	4	5	0	0	0	16	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-012	M	2	0	1	2	2	0	1	0	3	7	8	0	0	17	0	0	0	2:30	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	6	1	1	0	0	10	0	1	0	2:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	5	1	2	0	0	9	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-015	M	3	0	0	2	3	0	2	0	1	0	4	0	0	11	0	2	0	2:00	0	0	0	0	0	0	1	S-NA
R-016	B	3	0	3	3	11	0	3	0	10	3	3	0	0	11	0	1	0	7:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	0	5	5	0	0	15	0	0	0	3:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	4	0	0	0	14	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	6	4	0	0	15	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	3	4	1	0	0	16	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-021	W	1	0	0	1	0	0	1	0	2	5	3	0	0	13	2	0	0	3:00	0	0	0	2	1	1	1	S-A
R-022	W	0	0	0	0	0	0	0	0	1	4	2	0	0	14	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-023	W	1	0	0	1	0	0	1	0	4	5	0	0	0	15	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	2	0	0	1	1	0	3	0	1	3	4	0	0	14	0	0	0	2:30	0	0	0	0	0	0	1	S-A
R-025	G	2	0	1	1	1	0	2	0	2	4	2	0	0	14	1	0	0	3:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 6 TRACK WIDTH 4.5' LENGTH 25' RADIUS 8'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	4	0	0	2	3	0	4	0	3	1	7	0	0	10	0	1	0	3:00	0	0	0	0	3	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	4	0	0	2	7	0	4	0	1	1	4	0	0	10	0	0	0	2:00	0	0	0	2	2	1	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	5	1	2	0	0	12	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-005	G	1	0	0	1	4	0	1	0	1	1	4	0	0	8	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-006	G	1	0	3	1	0	0	1	0	7	1	1	0	0	12	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	0	0	1	0	0	6	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-008	G	1	0	0	1	3	0	1	0	1	1	6	0	0	11	0	0	0	2:00	0	0	0	1	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	5	0	2	0	0	12	0	0	0	1:30	0	0	0	3	0	3	29	S-NA
R-010	M	4	0	4	1	2	0	3	1	5	2	3	0	0	11	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-011	M	4	1	2	4	1	0	4	1	10	3	2	0	0	14	0	2	0	4:30	0	0	0	0	0	0	29	M-A
R-012	M	3	1	2	6	3	0	3	0	1	1	5	0	0	8	0	1	0	3:00	1	1	0	2	2	2	1	S-A
R-013	M	0	0	0	0	0	0	0	0	3	6	4	0	0	16	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	1	0	1	1	0	0	1	0	2	4	4	0	0	16	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	1	0	0	1	0	1	1	2	0	0	6	0	0	0	2:00	0	0	0	0	1	0	1	S-NA
R-016	B	1	0	1	1	3	0	1	0	2	6	15	0	1	25	0	0	0	4:30	0	0	0	0	0	0	1	M-A
R-017	W	1	0	1	2	2	0	1	0	1	2	4	0	0	12	0	0	0	3:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	0	1	0	0	12	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	0	0	2	0	0	11	0	1	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	2	1	0	0	1	0	3	0	2	0	0	11	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	2	0	1	2	2	0	2	0	2	1	6	0	0	11	0	0	0	2:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	1	0	7	0	2	0	0	12	0	0	0	1:30	0	0	0	0	0	1	29	S-A
R-023	W	1	0	0	1	1	0	1	0	0	0	2	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	1	1	1	0	1	0	2	1	5	0	1	11	0	0	0	2:30	0	0	0	0	0	1	1	S-A
R-025	G	1	0	5	3	1	0	2	0	7	2	2	0	0	10	2	0	0	2:30	0	0	0	0	1	1	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 7 TRACK WIDTH 4.5' LENGTH 12' RADIUS 12'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	1	0	0	1	0	0	2	0	1	2	2	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	1	0	0	1	0	0	1	1	0	2	1	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	1	1	1	0	0	5	0	0	0	0:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	0	2	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	2	1	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	0	0	0	0	6	0	0	0	0:30	0	0	0	0	0	1	29	M-A
R-008	G	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	1	0	4	1	0	0	1	0	1	1	0	0	0	3	0	0	0	1:30	0	0	0	0	0	0	29	S-NA
R-010	M	0	0	0	0	0	0	0	0	2	2	1	0	0	5	0	0	0	0:30	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	0	1	1	0	0	6	0	0	0	0:30	0	0	0	0	0	0	29	M-A
R-012	M	0	0	0	0	0	0	0	0	3	2	1	0	0	5	0	0	0	0:30	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	1	0	2	0	0	10	0	1	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	6	0	2	0	0	12	0	0	0	0:30	0	0	0	0	0	0	29	S-A
R-015	M	1	0	2	2	0	0	1	0	4	4	4	0	0	9	0	1	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	1	0	0	0	5	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	1	2	2	0	0	7	0	0	0	0:30	0	0	0	0	0	0	29	M-NA
R-021	W	1	0	1	0	0	0	1	0	3	2	1	0	0	6	0	1	0	2:00	0	0	0	0	1	0	1	S-A
R-022	W	1	0	1	0	0	0	0	0	1	3	1	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	0	3	2	0	0	5	0	0	0	0:30	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	1	0	0	1	1	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-025	G	3	0	2	1	1	0	3	0	3	0	2	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 8 TRACK WIDTH 4.5' - 3.5' LENGTH 17' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	0	0	0	0	0	0	0	0	3	3	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	1	0	1	0	1	0	1	0	2	1	1	0	0	9	0	0	0	2:00	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	1	1	1	0	0	8	0	0	0	0:30	0	0	0	0	0	2	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	3	3	1	0	0	7	0	0	0	3:00	0	0	0	0	0	1	1	M-A
R-006	G	0	0	0	0	0	0	0	0	2	4	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	3	4	2	0	0	13	0	0	0	1:00	0	0	0	0	0	2	29	M-A
R-008	G	3	0	2	1	1	0	3	0	2	2	0	0	0	8	0	0	0	1:30	0	0	0	0	0	1	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	3	1	2	0	0	9	0	0	0	1:00	0	0	1	3	3	2	29	S-NA
R-010	M	3	0	1	2	1	0	2	0	2	2	3	0	0	8	0	0	0	1:30	0	0	1	2	2	1	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	1	3	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-012	M	0	0	0	0	0	0	0	0	9	4	1	0	0	15	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	2	3	1	0	0	5	0	0	0	2:00	0	0	0	0	0	1	1	S-A
R-014	M	0	0	0	0	0	0	0	0	0	1	0	0	0	4	0	1	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	1	0	0	1	2	0	1	0	3	0	1	0	0	6	0	0	0	1:30	0	0	0	2	0	1	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	3	3	1	0	0	10	0	0	0	2:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	3	2	0	0	0	8	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	2	1	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	1	1	0	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	0	3	2	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	2	0	1	3	1	0	2	0	3	3	2	0	0	8	0	0	0	3:00	0	0	0	0	0	0	1	S-A
R-022	W	1	0	1	2	0	0	1	0	1	2	2	0	0	9	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	1	1	0	0	0	8	0	0	0	0:30	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	1	0	0	0	2	0	4	1	2	0	0	10	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	1	0	1	2	0	0	1	0	1	2	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 9 TRACK WIDTH 3.5' LENGTH 26' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	9	0	9	5	2	0	10	0	8	3	4	0	0	16	0	1	0	4:30	0	0	0	3	3	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	6	1	5	4	1	0	6	0	5	2	3	0	0	12	0	0	0	4:30	0	0	0	2	7	2	1	M-NA
R-004	G	1	0	1	1	2	0	1	0	1	1	4	0	0	10	0	0	0	2:00	0	0	0	3	2	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	1	3	2	2	0	0	15	0	0	0	2:00	0	0	0	0	6	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	5	2	3	1	0	12	0	1	0	2:00	0	0	0	4	2	4	29	M-A
R-007	G	1	0	0	1	2	0	1	0	3	1	2	1	0	13	0	1	0	2:30	0	0	1	3	1	7	29	M-A
R-008	G	1	0	0	0	2	0	1	0	4	1	3	0	0	13	0	0	0	1:30	0	0	0	2	2	3	1	S-NA
R-009	G	1	0	0	1	0	0	1	0	2	1	3	0	0	7	0	0	0	1:30	0	0	1	1	0	3	29	S-NA
R-010	M	5	1	1	4	7	0	5	1	5	3	0	4	0	12	0	1	0	4:00	0	2	0	3	4	2	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	4	1	5	0	0	15	0	2	0	2:00	0	1	0	1	4	1	29	M-A
R-012	M	1	0	3	1	0	0	1	0	0	1	2	0	0	6	0	0	0	2:00	0	0	0	0	6	0	1	S-A
R-013	M	1	0	2	2	0	0	1	0	4	7	5	0	0	9	0	0	0	1:30	0	0	0	2	5	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	1	3	2	0	0	8	0	0	0	4:30	0	0	0	3	2	3	29	S-A
R-015	M	2	0	3	1	0	0	2	2	2	2	4	0	0	9	0	3	0	2:30	0	0	0	3	2	5	1	S-NA
R-016	B	1	0	1	2	2	0	1	0	3	2	6	0	0	13	0	0	0	5:00	0	0	0	0	0	1	1	M-A
R-017	W	1	0	3	1	1	0	1	0	7	2	3	0	0	15	0	0	0	3:00	0	0	0	0	1	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	2	2	0	0	7	0	1	0	3:00	0	0	0	3	1	3	29	M-A
R-019	M	0	0	0	0	0	0	0	2	3	1	5	0	0	14	0	1	0	2:00	0	0	0	1	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	4	1	4	0	0	13	0	2	0	1:30	0	0	0	1	0	0	29	M-NA
R-021	W	1	0	2	0	1	0	1	0	5	1	0	0	0	11	0	0	0	3:00	0	0	0	0	1	0	1	S-A
R-022	W	1	0	0	0	1	0	1	0	2	1	5	0	0	11	0	1	0	2:00	0	0	0	0	1	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	6	2	4	0	0	13	0	0	0	1:30	0	0	0	2	1	0	1	S-NA
R-024	G	1	0	0	1	0	0	1	0	2	1	5	0	0	13	0	0	0	2:00	0	0	0	2	1	0	1	S-A
R-025	G	2	0	1	1	2	0	2	0	5	1	4	0	0	13	0	2	0	2:30	0	0	0	1	2	3	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 10 TRACK WIDTH 3.5' LENGTH 17' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	3	0	1	2	1	0	3	0	4	3	3	0	0	8	0	0	0	2:00	0	0	0	0	0	0	1	M-NA
R-002	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	M-NA
R-003	G	1	0	1	0	0	0	1	0	1	3	2	0	0	8	0	0	0	1:00	0	0	0	0	1	1	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	1	1	1	0	0	8	0	0	0	1:00	0	0	0	1	0	0	29	M-NA
R-005	G	1	0	1	0	1	0	1	0	1	3	1	0	0	7	0	0	0	1:30	0	0	0	1	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	2	3	3	0	0	9	0	0	0	1:30	0	0	0	1	1	1	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	3	3	0	0	8	0	0	0	2:00	0	0	0	1	1	0	29	M-A
R-008	G	2	0	1	1	0	0	2	0	1	3	2	0	0	8	0	0	0	2:00	0	0	0	2	1	0	1	S-NA
R-009	G	1	0	1	0	0	0	1	0	2	2	1	0	0	9	0	0	0	1:30	0	0	0	0	0	0	29	S-NA
R-010	M	2	0	1	1	0	0	2	0	3	6	5	0	0	8	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	2	4	3	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-012	M	1	0	2	1	0	0	0	0	1	2	1	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-013	M	1	0	2	1	0	0	1	1	2	4	3	0	0	19	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	3	1	1	4	5	0	3	0	0	1	9	0	0	10	0	1	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	0	0	1	2	1	0	0	9	0	0	0	1:00	0	0	0	1	1	1	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	3	1	0	0	8	0	0	0	2:00	0	0	0	1	0	1	1	M-A
R-017	W	0	0	0	0	0	0	0	0	2	3	1	0	0	6	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	3	5	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	0	4	3	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	0	1	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	3	0	1	3	1	0	3	0	5	5	5	0	0	11	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	1	0	1	2	1	0	0	8	0	0	0	:30	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	3	2	1	0	0	9	0	0	0	:30	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	1	2	1	0	2	2	0	1	1	0	0	9	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	2	0	2	1	0	0	4	0	2	3	2	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 11 TRACK WIDTH 5.5' LENGTH 15' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	3	0	1	0	2	0	2	0	0	2	1	0	0	6	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-002	G	2	0	0	2	2	0	3	0	2	0	4	0	0	5	0	0	0	2:30	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	0	1	1	0	2	0	1	2	0	0	0	7	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	2	0	1	2	0	0	2	0	2	1	5	0	0	6	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-005	G	1	0	1	1	3	0	1	0	2	3	0	0	0	6	0	0	0	2:30	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	1	2	2	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	3	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-008	G	1	0	0	1	0	0	1	0	4	3	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	0	1	3	0	0	6	0	0	0	:30	0	0	0	0	0	0	29	S-NA
R-010	M	1	0	3	1	0	0	1	1	0	1	2	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	1	2	1	0	1	0	1	3	3	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-012	M	2	0	3	3	2	0	3	0	2	3	4	0	0	11	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	2	1	1	0	0	10	0	2	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	1	0	1	1	0	0	1	0	4	5	2	0	0	9	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	1	0	2	1	0	0	1	0	2	1	2	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	1	0	0	0	7	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	2	2	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	0	1	3	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	1	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	1	2	1	5	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	2	0	1	1	0	0	0	0	1	2	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	1	0	0	1	0	0	1	0	1	2	0	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	8	1	2	0	0	0	7	0	0	0	1:00	0	0	0	1	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	1	2	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-025	G	2	0	0	2	1	0	2	1	1	3	2	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 12 TRACK WIDTH 5.5' LENGTH 13' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	6	0	2	5	4	2	5	1	0	1	8	1	0	8	0	2	0	9:00	2	0	0	3	1	0	1	M-NA
R-002	G	3	0	0	2	6	0	3	0	0	2	1	0	0	6	0	1	0	3:00	1	0	0	1	1	0	11	M-NA
R-003	G	1	0	0	1	1	0	1	0	0	1	3	0	0	5	0	1	0	1:00	0	0	0	0	0	0	1	M-NA
R-004	G	1	0	3	1	0	0	1	1	3	2	0	0	0	8	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	0	0	4	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	1	0	0	0	0	0	6	0	0	0	:30	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	1	2	0	0	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-008	G	1	0	0	1	3	0	1	0	1	0	5	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	2	0	1	0	0	9	0	0	0	1:00	0	0	0	0	0	2	29	S-NA
R-010	M	4	1	4	3	2	0	1	0	6	0	1	0	0	6	0	1	0	3:30	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	2	1	1	0	1	1	6	1	2	0	0	12	0	3	0	2:30	0	0	0	0	0	0	29	M-A
R-012	M	1	0	1	1	3	0	1	0	1	1	3	1	2	3	0	2	0	2:30	0	0	0	0	0	0	1	S-A
R-013	M	2	1	3	4	8	0	4	0	4	2	10	1	0	13	0	11	0	6:30	No errors tab., rdwy not visible due to sun angle						1	S-A
R-014	M	1	0	1	2	1	0	1	0	2	3	3	0	0	8	0	1	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	1	0	0	0	2	0	1	0	0	0	2	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	0	4	0	0	6	0	0	0	2:30	0	0	0	1	1	2	1	M-A
R-017	W	0	0	0	0	0	0	0	0	0	0	3	1	0	5	0	1	0	2:00	0	0	0	1	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	2	0	0	0	0	4	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	0	4	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	5	2	0	0	2	2	2	0	3	0	0	7	0	2	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	0	0	3	0	0	2	0	0	0	2:00	0	0	0	2	0	0	1	S-A
R-022	W	0	0	1	0	0	0	1	0	4	0	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	1	0	0	1	3	0	1	0	1	0	5	1	0	8	0	3	0	2:00	1	0	0	1	2	0	1	S-NA
R-024	G	1	0	1	2	4	0	1	0	0	0	5	0	0	6	0	0	0	3:00	0	0	0	1	0	0	1	S-A
R-025	G	0	0	0	0	0	0	0	0	3	0	1	0	0	6	0	0	0	:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 13 TRACK WIDTH 5.5' LENGTH 24' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	0	1	0	0	2	0	3	5	1	0	0	10	0	0	0	2:30	0	0	0	0	0	0	11	M-NA
R-003	G	1	0	0	1	0	0	1	0	0	2	1	0	0	10	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	2	0	0	1	1	0	2	0	2	2	1	0	0	11	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	1	0	1	3	2	0	0	9	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	3	2	0	0	10	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	0	1	1	0	0	10	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-008	G	2	0	1	1	0	0	2	0	4	3	2	0	0	9	0	0	0	2:30	0	0	0	5	4	2	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	4	4	2	0	0	11	0	0	0	2:00	0	0	0	1	0	2	29	S-NA
R-010	M	0	0	0	0	0	0	0	0	1	2	1	0	0	8	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	4	3	0	0	0	10	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-012	M	2	0	4	2	0	0	1	0	6	4	1	0	0	10	0	0	0	2:00	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	3	4	2	0	0	11	0	2	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	4	1	2	0	0	6	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	0	0	0	1	0	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	1	2	2	0	1	0	1	4	2	0	0	9	0	0	0	3:00	0	0	0	1	1	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	0	2	1	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	2	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	0	0	0	0	0	1	4	3	0	0	10	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	3	0	0	3	6	0	2	0	1	3	3	2	0	13	0	0	0	3:00	0	0	0	0	0	0	1	S-A
R-022	W	2	0	1	2	0	0	1	0	0	2	2	0	0	13	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	1	2	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	1	0	0	0	1	0	4	1	0	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-025	G	1	0	1	0	0	0	1	0	1	2	1	0	0	11	0	0	0	1:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 14 TRACK WIDTH 5.5' LENGTH 14' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	2	0	2	0	0	0	2	0	3	0	0	0	0	3	0	0	0	1:00	0	0	0	0	1	0	11	M-NA
R-003	G	2	0	4	1	0	0	1	0	3	0	0	0	0	4	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	1	0	0	1	3	0	1	0	0	1	4	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	7	1	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	1	0	0	1	4	0	1	0	2	1	2	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1:00	0	0	0	0	0	2	29	M-A
R-008	G	1	0	1	0	0	0	1	0	4	0	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	2	0	1	1	4	0	2	0	1	1	6	0	0	7	0	1	0	1:30	2	0	2	2	2	1	29	S-NA
R-010	M	1	0	0	1	2	0	1	0	2	0	0	0	0	1	0	0	0	3:00	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	0	2	3	0	1	0	0	1	6	1	0	8	0	2	0	2:30	0	0	0	0	0	0	29	M-A
R-012	M	1	0	3	2	1	0	2	1	3	1	0	0	0	9	0	1	0	2:00	0	0	0	1	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	2	0	1	0	0	9	0	1	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	2	2	1	0	0	11	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	2	0	3	1	1	0	2	2	3	0	3	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	8	0	5	0	0	12	0	1	0	4:00	0	0	0	2	0	3	1	M-A
R-017	W	0	0	0	0	0	0	0	0	4	0	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	1	0	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	2	1	0	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	3	0	4	1	0	7	0	1	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	1	0	0	0	0	0	0	1	6	4	2	0	0	18	0	0	0	1:00	0	0	0	0	0	1	1	S-A
R-022	W	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0	0	1:30	0	0	0	2	0	2	29	S-A
R-023	W	0	0	0	0	0	0	0	0	3	0	1	0	0	9	0	0	0	:30	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	2	0	2	0	0	9	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-025	G	1	0	1	2	0	0	1	0	0	1	5	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 15 TRACK WIDTH 5.5' LENGTH 18' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	1	2	0	0	1	0	1	2	1	0	0	9	0	0	0	2:00	0	0	0	0	0	0	11	M-NA
R-003	G	3	0	1	1	1	0	2	0	0	1	0	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	2	3	0	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	1	2	1	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	1	2	1	0	0	7	0	0	0	1:30	0	0	0	1	0	1	29	M-A
R-007	G	1	0	0	2	3	0	1	0	1	2	6	0	0	12	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-008	G	1	0	0	1	0	0	1	0	3	4	0	0	0	8	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	1	2	2	0	0	7	0	0	0	1:30	0	0	0	0	0	1	29	S-NA
R-010	M	7	1	1	5	8	0	7	0	4	4	6	1	0	13	0	1	0	1:30	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	2	1	1	0	0	9	0	1	0	1:00	0	0	0	0	0	0	29	M-A
R-012	M	2	0	2	2	0	0	2	0	0	1	4	0	0	8	0	1	0	2:00	0	0	0	0	0	0	1	S-A
R-013	M	1	0	1	1	0	0	1	0	2	3	1	0	0	7	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-014	M	1	0	1	2	3	0	1	0	1	0	3	1	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	0	0	0	2	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	2	0	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	2	0	0	0	6	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	0	4	0	0	7	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	0	3	3	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	1	2	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	1	0	1	0	1	0	1	0	0	3	0	0	0	1:00	0	0	0	1	0	0	1	S-A
R-022	W	1	0	0	0	1	0	1	0	0	0	1	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	3	3	2	0	0	8	0	0	0	1:00	0	0	0	1	0	0	1	S-NA
R-024	G	2	0	1	2	0	0	2	0	2	0	0	0	0	7	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	2	0	0	1	1	0	2	0	1	2	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 16 TRACK WIDTH 5.5' LENGTH 12' RADIUS 8'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	2	0	0	2	5	0	2	0	0	0	2	0	0	5	0	0	0	1:00	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	0	2	3	0	2	0	1	0	3	0	0	5	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	1	2	0	1	0	0	3	0	1	0	1:00	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	3	0	0	0	0	4	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	1	1	0	0	0	0	5	0	0	0	:30	0	0	0	1	0	2	29	M-A
R-008	G	1	0	0	1	4	0	1	0	0	0	2	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	3	0	1	0	0	6	0	0	0	:30	0	0	0	2	0	1	29	S-NA
R-010	M	1	0	2	1	0	0	0	0	3	0	1	0	0	5	0	0	0	:30	0	0	0	0	0	0	29	M-NA
R-011	M	1	1	1	1	0	0	1	0	5	1	0	0	0	6	0	2	0	1:30	0	0	0	0	0	0	29	M-A
R-012	M	1	0	2	4	2	0	1	0	0	0	1	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-013	M	1	0	0	1	2	0	1	0	0	1	3	0	0	6	0	1	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	0	1	0	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	1	0	0	0	2	0	1	0	1	0	2	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	0	3	0	0	5	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-017	W	1	0	1	2	1	0	1	0	0	0	3	0	0	6	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	3	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	1	2	0	0	0	3	0	1	0	0	5	0	1	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	0	0	2	0	0	1	0	0	0	1:00	0	0	0	1	2	1	1	S-A
R-022	W	1	0	0	1	0	0	1	0	3	2	1	0	0	5	0	0	0	:30	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	1:00	0	0	0	1	1	1	1	S-NA
R-024	G	4	0	0	0	2	0	2	0	1	2	4	0	0	10	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-025	G	0	0	0	0	0	0	0	0	1	0	0	0	0	5	0	0	0	:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 17 TRACK WIDTH 5.5' LENGTH 13' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	3	0	0	1	2	0	3	0	1	4	3	0	0	8	0	0	0	:30	0	0	3	0	1	1	11	M-NA
R-003	G	0	0	0	0	0	0	0	0	0	1	0	0	0	6	0	0	0	1:30	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	4	3	1	0	0	10	0	0	0	?	0	0	4	4	4	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	1	1	0	0	0	6	0	0	0	1:00	0	0	0	0	0	3	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	2	1	0	0	8	0	0	0	1:00	0	0	0	0	2	5	29	M-A
R-007	G	0	0	0	0	0	0	0	0	1	2	0	0	0	6	0	0	0	1:30	0	1	2	1	2	1	29	M-A
R-008	G	2	0	2	1	0	0	2	0	1	3	2	0	0	7	0	0	0	1:30	0	0	0	0	0	3	1	S-NA
R-009	G	1	0	0	1	1	0	1	0	0	2	1	0	0	8	0	0	0	1:30	0	0	3	0	3	1	29	S-NA
R-010	M	2	1	1	1	2	0	1	0	1	1	4	0	0	8	0	0	0	1:30	0	0	1	0	0	5	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	1	2	1	0	0	9	0	0	0	:30	0	0	0	0	0	0	29	M-A
R-012	M	1	0	1	2	2	0	0	0	1	1	1	0	0	10	0	0	0	2:00	0	0	0	0	1	2	1	S-A
R-013	M	1	0	1	1	0	0	1	0	1	2	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	4	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	1	1	3	1	5	1	0	7	0	0	0	2:00	0	0	2	0	1	3	1	S-NA
R-016	B	1	0	1	2	3	0	1	0	0	3	3	0	0	7	0	0	0	3:00	0	0	0	0	0	1	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	2	1	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	0	2	0	0	4	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	0	1	0	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	0	1	2	0	0	8	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	1	0	1	1	0	0	1	0	1	1	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	1	0	3	1	0	0	0	10	0	0	0	:30	0	0	0	0	1	4	29	S-A
R-023	W	0	0	0	0	0	0	0	0	0	2	2	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	1	2	2	0	1	0	2	0	1	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	1	0	1	0	0	0	1	0	1	2	1	0	0	6	0	0	0	1:30	0	0	0	0	0	3	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 18 TRACK WIDTH 5.5' LENGTH 19' RADIUS 8'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	4	0	0	3	3	0	5	0	0	2	7	0	0	10	0	0	0	1:00	0	0	0	0	0	0	11	M-NA
R-003	G	3	0	0	2	5	0	2	0	0	0	4	0	0	5	0	0	0	1:00	0	0	1	1	0	1	1	M-NA
R-004	G	2	0	3	0	0	0	2	0	3	2	2	0	0	10	0	0	0	2:00	2	2	2	0	1	1	29	M-NA
R-005	G	1	0	0	1	3	0	1	0	0	3	7	1	0	6	0	2	0	3:00	Errors not tab. vehicle step switch malf.						1	M-A
R-006	G	0	0	0	0	0	0	0	0	7	2	2	0	0	10	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	1	2	0	3	0	0	10	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-008	G	2	0	0	2	6	0	2	0	3	0	5	1	0	7	0	1	0	3:00	Errors not tab. vehicle step switch malf.						1	M-A
R-009	G	2	0	4	3	0	0	2	0	4	0	2	0	0	10	0	0	0	2:30	0	0	2	4	3	2	29	S-NA
R-010	M	3	0	5	2	0	0	3	0	4	0	3	0	0	8	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	3	3	0	0	1	0	7	1	4	0	0	10	0	4	0	1:00	0	0	0	1	0	0	29	M-A
R-012	M	1	0	2	5	2	0	2	0	1	0	4	0	0	10	0	5	0	2:30	0	0	0	0	0	1	1	S-A
R-013	M	0	0	0	0	0	0	0	0	1	1	4	0	0	9	0	1	0	1:30	0	0	0	0	1	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	2	0	1	0	0	9	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	1	0	1	0	0	0	1	0	1	0	3	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	5	2	2	5	18	0	5	0	1	3	6	3	0	12	0	4	0	18:00	3	1	0	2	1	3	1	M-A
R-017	W	2	1	0	1	0	0	2	0	5	1	5	1	0	10	0	4	0	5:00	0	0	0	2	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	2	2	0	0	9	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	1	2	0	0	0	0	5	0	0	0	:30	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	2	1	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	3	0	3	0	0	9	0	0	0	1:00	0	0	0	1	0	1	1	S-A
R-022	W	1	0	1	0	0	0	1	1	5	1	2	0	0	8	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	0	0	3	0	0	5	0	0	0	:30	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	1	0	0	0	1	0	2	3	1	0	0	8	0	0	0	3:00	0	0	0	3	3	2	1	S-A
R-025	G	1	0	0	1	0	0	1	0	2	0	2	0	0	9	0	0	0	1:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 19 TRACK WIDTH 5.5' - 3.5' LENGTH 15' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	4	0	3	2	0	0	3	0	2	3	0	0	0	5	0	0	0	2:00	0	0	0	0	0	0	11	M-NA
R-003	G	5	0	2	2	1	0	5	0	4	5	2	0	0	9	0	0	0	3:00	0	0	0	0	0	1	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	0	2	1	0	0	7	0	0	0	1:30	0	0	0	3	3	2	29	M-NA
R-005	G	1	0	2	1	0	0	1	0	4	4	3	0	0	9	0	0	0	2:00	0	0	0	0	0	1	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	1	0	0	0	8	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	1	1	0	0	6	0	0	0	2:00	0	0	0	0	0	3	29	M-A
R-008	G	0	0	0	0	0	0	0	0	3	3	1	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	1	0	0	0	1	0	1	0	1	2	0	0	0	6	0	0	0	1:30	0	0	0	1	0	0	29	S-NA
R-010	M	1	0	1	1	0	0	2	0	2	4	3	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	5	4	1	0	0	8	0	0	0	1:30	0	0	0	0	1	1	29	M-A
R-012	M	1	0	1	2	1	0	1	0	2	2	1	0	0	9	0	0	0	1:30	0	0	0	2	1	5	1	S-A
R-013	M	0	0	0	0	0	0	0	0	1	2	1	0	0	7	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-014	M	1	0	1	2	1	0	1	0	2	1	2	0	0	8	0	0	0	1:00	0	0	0	0	0	1	29	S A
R-015	M	2	0	1	1	1	0	1	0	4	4	3	0	0	9	0	0	0	1:30	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	0	3	1	0	0	8	0	0	0	3:00	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	2	4	2	0	0	8	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	0	2	0	0	7	0	0	0	2:30	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	4	3	0	0	9	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	2	5	3	0	0	9	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	1	1	0	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	0	0	0	1	0	0	0	6	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	1	2	1	0	0	8	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	1	0	0	0	0	4	0	0	0	2:30	0	0	0	0	0	0	1	S-NA
R-025	G	1	0	5	2	1	0	2	0	3	3	0	0	0	8	0	0	0	2:30	0	0	0	0	0	0	29	S-NA

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 20 TRACK WIDTH 3.5' LENGTH 9' RADIUS 10'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	0	0	0	0	0	0	1	0	1	1	0	0	0	4	0	0	0	:30	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	3	1	0	0	2	0	3	0	0	0	0	3	0	0	0	1:00	1	0	1	1	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	0	0	1	0	0	2	0	0	0	:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	2	1	1	0	0	3	0	0	0	:30	0	0	0	0	0	0	1	N-A
R-006	G	0	0	0	0	0	0	0	0	0	0	2	0	0	4	0	0	0	:30	0	0	0	0	0	0	29	N-A
R-007	G	0	0	0	0	0	0	0	0	0	1	2	0	0	6	0	0	0	:30	0	0	0	0	0	0	29	N-A
R-008	G	0	0	0	0	0	0	0	0	3	1	2	0	0	6	0	0	0	:30	0	0	0	2	0	1	1	S-NA
R-009	G	1	0	2	1	1	0	1	0	0	2	4	0	0	5	0	0	0	1:00	0	0	0	2	0	2	29	S-NA
R-010	M	1	0	0	0	1	0	0	0	2	4	5	0	0	8	0	0	0	1:00	1	1	0	0	1	1	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	0	1	3	0	0	3	0	2	0	2:00	0	0	0	1	0	0	29	N-A
R-012	M	2	0	2	2	0	0	2	0	1	2	2	0	0	5	0	1	0	:30	0	0	0	0	0	0	1	S-A
R-013	M	2	0	2	1	0	0	2	0	5	0	1	0	0	3	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	2	2	0	0	0	9	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	0	0	0	0	0	0	0	1	0	0	2	0	0	2	0	0	0	:30	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	4	1	0	0	0	3	0	0	0	1:00	0	0	0	0	0	0	1	N-A
R-017	W	0	0	0	0	0	0	0	0	2	1	1	0	0	2	0	0	0	1:00	0	0	0	0	0	0	1	N-A
R-018	W	0	0	0	0	0	0	0	0	2	0	0	0	0	2	0	0	0	:30	0	0	0	0	0	0	29	N-A
R-019	M	0	0	0	0	0	0	0	0	3	0	1	0	0	3	0	0	0	.30	0	0	0	0	0	0	1	N-A
R-020	W	0	0	0	0	0	0	1	0	0	0	2	0	0	1	0	0	0	:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-022	W	2	0	1	2	1	0	3	0	0	2	4	0	0	4	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	2	0	0	0	0	3	0	0	0	:30	0	0	0	0	0	0	1	S-NA
R-024	G	3	0	1	3	2	0	5	0	1	3	3	0	0	13	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-025	G	2	0	0	1	2	0	2	0	0	1	3	0	0	3	0	0	0	:30	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 21 TRACK WIDTH 3.5' - 4.5' LENGTH 24' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	0	0	1	0	1	0	1	1	1	0	0	9	0	0	0	3:00	0	0	0	0	0	0	11	M-NA
R-003	G	1	0	0	1	0	0	1	0	1	5	4	0	0	13	0	0	0	2:00	0	0	0	0	0	0	1	M-NA
R-004	G	1	0	0	0	0	0	1	0	1	3	3	0	0	14	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	2	4	1	0	0	12	0	0	0	2:00	0	0	0	0	0	0	1	N-A
R-006	G	0	0	0	0	0	0	0	0	3	5	1	0	0	12	0	0	0	1:30	0	0	0	0	0	0	29	N-A
R-007	G	0	0	0	0	0	0	0	0	1	2	0	0	0	14	0	0	0	1:00	0	0	0	0	0	0	29	N-A
R-008	G	0	0	0	0	0	0	0	0	1	2	1	0	0	9	0	0	0	1:30	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	1	1	1	0	0	14	0	0	0	1:30	0	0	0	0	0	1	29	S-NA
R-010	M	1	1	0	1	3	0	1	0	3	4	4	0	0	8	0	0	0	2:00	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	1	2	1	0	1	0	3	3	3	0	0	14	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-012	M	1	0	4	2	0	0	1	0	3	7	3	0	0	10	0	0	0	3:00	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	3	8	6	0	0	15	0	0	0	2:00	0	0	0	0	0	0	1	S-A
R-014	M	1	0	1	1	2	0	1	0	1	0	2	0	0	4	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-015	M	2	0	1	1	3	0	2	0	2	3	3	0	0	14	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	3	1	0	0	11	0	0	0	2:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	2	6	4	0	0	14	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	3	2	2	0	0	12	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	1	1	1	0	0	13	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	1	0	0	0	0	1	3	3	0	0	15	0	0	0	2:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	3	4	2	0	0	14	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	0	0	0	1	0	0	0	12	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	1	3	1	0	0	13	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	2	0	3	0	0	9	0	0	0	4:30	0	0	0	0	0	0	1	S-A
R-025	G	1	0	0	1	0	0	1	0	2	4	2	0	0	14	0	0	0	2:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 22 TRACK WIDTH 4.5' LENGTH 24' RADIUS 8'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	3	0	0	3	1	0	4	0	1	2	6	0	0	11	0	0	0	1:00	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	0	2	6	0	2	0	2	1	5	0	0	10	0	1	0	2:30	1	0	0	2	2	1	1	M-NA
R-004	G	2	0	3	1	0	0	2	0	5	1	1	0	0	11	0	0	0	2:00	0	0	0	1	3	1	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	1	2	9	0	0	11	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	7	1	4	0	0	12	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	4	0	2	0	0	11	0	0	0	1:30	0	0	0	0	0	0	29	M-A
R-008	G	2	0	0	1	5	0	2	0	2	0	3	0	0	9	0	0	0	2:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	4	0	2	0	0	13	0	0	0	1:00	0	0	0	1	0	1	29	S-NA
R-010	M	4	0	6	4	0	0	5	0	4	1	2	0	0	12	0	0	0	2:30	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	4	1	0	0	0	0	1	1	0	0	0	4	0	0	0	4:00	0	0	0	0	0	0	29	M-A
R-012	M	3	0	4	6	5	0	3	0	3	1	8	0	0	11	0	0	0	2:00	0	0	0	0	0	0	1	S-A
R-013	M	1	0	1	2	2	0	0	0	2	0	3	0	0	10	0	2	0	1:30	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	1	3	2	0	0	13	0	0	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	2	0	1	1	2	0	2	0	5	0	5	0	0	10	0	1	0	1:30	0	0	0	1	1	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	0	4	0	0	10	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-017	W	1	0	1	2	2	0	1	0	3	6	10	0	0	22	0	0	0	3:00	0	0	0	0	0	0	1	M-A
R-018	W	1	0	1	1	0	0	1	0	1	2	1	0	0	13	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	2	1	0	1	0	0	3	0	3	0	0	8	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-020	W	1	0	3	2	0	0	2	0	4	0	2	0	0	12	0	1	0	2:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	5	0	7	0	0	11	0	0	0	1:00	0	0	0	0	0	1	1	S-A
R-022	W	4	0	2	2	0	0	4	2	11	5	3	0	0	17	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-023	W	0	0	0	0	0	0	0	0	2	0	4	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-024	G	1	0	1	2	0	0	1	0	1	2	1	0	0	6	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	0	0	0	0	0	0	0	0	5	1	3	0	0	10	0	0	0	2:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 23 TRACK WIDTH 4.5' - 3.5' LENGTH 10 RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	2	1	0	0	2	0	2	1	1	0	0	3	0	0	0	1:30	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	0	1	1	0	2	0	1	3	3	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	1	1	0	0	0	4	0	0	0	:30	0	0	0	0	0	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	5	2	1	0	0	10	0	0	0	:30	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	2	1	0	0	0	4	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	1	3	2	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-008	G	1	0	0	1	2	0	1	0	4	3	2	0	0	12	0	1	0	1:00	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	0	2	1	0	0	5	0	0	0	1:00	0	0	0	1	0	0	29	S-NA
R-010	M	1	0	1	0	0	0	1	0	1	3	2	0	0	3	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	1	1	0	0	1	0	4	1	3	0	1	10	0	6	0	:30	0	0	0	0	1	1	29	M-A
R-012	M	0	0	0	0	0	0	0	0	0	2	2	0	0	4	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-013	M	0	0	0	1	0	0	1	0	3	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	0	0	0	0	0	0	0	0	2	0	1	0	0	12	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	2	0	3	1	1	0	1	0	4	0	0	0	0	6	0	1	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	3	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	3	0	3	0	0	9	0	1	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	5	1	1	0	0	12	0	0	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	1	1	0	0	7	0	0	0	:30	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	1	0	0	1	0	2	2	1	0	0	4	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	9	2	1	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	1	0	0	2	4	0	1	0	0	0	2	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	3	2	7	5	3	0	5	1	15	2	4	0	0	11	0	5	0	1:00	0	0	0	0	0	0	1	S-A
R-025	G	2	0	2	2	0	0	2	1	1	1	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 24 TRACK WIDTH 3.5' LENGTH 5' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	2	0	5	1	0	0	1	0	1	0	0	0	0	5	0	0	0	1:00	0	0	0	0	2	2	11	M-NA
R-003	G	2	0	6	2	0	0	2	0	4	1	0	0	0	6	0	0	0	2:00	0	0	0	0	1	0	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	1:00	0	2	0	3	1	3	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	2	1	0	0	0	2	0	1	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	0	3	1	0	7	0	1	0	1:00	0	0	0	1	1	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	0	0	4	0	0	4	0	0	0	:30	0	0	0	0	0	1	29	M-A
R-008	G	0	0	0	0	0	0	0	0	0	1	1	0	0	3	0	0	0	2:00	0	0	0	2	0	3	1	S-NA
R-009	G	1	0	0	1	4	0	1	0	0	0	4	0	0	6	0	1	0	1:00	1	0	2	1	1	1	29	S-NA
R-010	M	4	0	0	2	4	0	4	0	1	0	2	2	0	5	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-011	M	1	0	2	1	0	0	1	0	2	2	0	0	0	2	0	0	0	2:00	0	0	0	0	2	0	29	M-A
R-012	M	2	0	5	2	0	0	2	1	4	0	1	0	0	7	0	0	0	1:30	0	0	0	1	6	0	1	S-A
R-013	M	0	0	0	0	0	0	0	0	3	0	0	0	0	7	0	2	0	1:00	0	0	0	2	5	0	1	S-A
R-014	M	3	0	3	5	6	0	4	0	2	2	4	1	0	10	0	0	0	2:00	0	0	0	1	1	1	29	S-A
R-015	M	0	0	0	1	0	0	1	0	2	0	1	0	0	5	0	0	0	1:00	0	0	0	2	3	1	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	0	1	0	0	6	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	2	1	0	0	4	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	1	0	0	0	3	0	0	0	1:00	0	0	0	1	0	1	29	M-A
R-019	M	0	0	0	0	0	0	0	0	4	0	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	0	0	0	0	0	0	0	1	0	0	3	0	0	0	:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	1	4	0	1	0	0	8	0	0	0	1:00	0	0	0	2	0	1	1	S-A
R-022	W	1	0	0	0	1	0	1	0	0	0	2	0	0	2	0	0	0	1:30	0	0	0	0	1	0	29	S-A
R-023	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	1	0	0	0	1	0	2	0	0	0	3	0	0	6	0	0	0	9:30	1	0	0	3	5	4	1	S-A
R-025	G	0	0	0	0	0	0	0	0	0	0	2	0	0	5	0	0	0	1:00	0	0	0	1	4	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 25 TRACK WIDTH 3.5' LENGTH 13' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	2	0	0	3	2	0	3	0	1	2	0	0	0	6	0	0	0	1:30	0	0	0	0	0	0	11	M-NA
R-003	G	2	0	2	1	1	0	2	0	0	1	0	0	0	4	0	0	0	1:30	0	0	0	0	0	1	1	M-NA
R-004	G	0	0	0	0	0	0	0	0	1	2	4	0	0	8	0	1	0	:30	0	0	0	1	1	0	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	1	3	4	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-006	G	0	0	0	0	0	0	0	0	2	3	1	0	0	5	0	0	0	:30	0	0	0	0	0	1	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	3	1	0	0	5	0	0	0	1:00	0	0	0	0	0	1	29	M-A
R-008	G	1	0	0	0	3	0	1	0	1	1	2	0	0	6	0	0	0	1:30	0	0	0	0	0	0	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	1	2	1	0	0	6	0	0	0	1:30	0	0	0	1	0	0	29	S-NA
R-010	M	1	0	0	1	0	0	1	0	1	3	1	0	0	4	0	0	0	1:30	0	0	0	0	1	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	3	1	0	0	0	5	0	0	0	1:00	0	0	0	2	2	2	29	M-A
R-012	M	5	2	4	3	2	0	4	0	2	5	2	0	0	6	0	1	0	3:00	0	0	0	1	0	3	1	S-A
R-013	M	0	0	0	0	0	0	0	0	1	3	3	0	0	7	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-014	M	2	0	2	3	1	0	1	0	1	2	2	0	0	6	0	1	0	1:30	0	0	0	0	0	0	29	S-A
R-015	M	2	0	1	0	1	0	2	0	1	3	7	1	0	13	0	1	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	3	2	0	0	4	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	0	3	0	0	5	0	0	0	1:00	0	0	0	1	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	0	3	0	0	7	0	1	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	1	2	3	0	0	7	0	0	0	:30	0	0	0	0	0	0	1	M-A
R-020	W	1	0	0	0	0	0	1	0	4	1	3	0	0	9	0	0	0	1:00	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	1	2	0	0	0	5	0	0	0	:30	0	0	0	0	0	0	1	S-A
R-022	W	0	0	0	0	0	0	0	0	1	3	0	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	1	0	3	0	0	6	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-025	G	1	0	0	0	1	0	1	0	1	3	4	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 26 TRACK WIDTH 3.5' LENGTH 13' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	0	0	1	0	1	0	0	0	3	0	0	5	0	0	0	:30	0	2	0	2	1	0	11	M-NA
R-003	G	3	0	0	1	5	0	3	0	0	0	3	0	0	7	0	0	0	1:00	0	0	0	2	2	1	1	M-NA
R-004	G	2	0	2	1	0	0	2	0	6	1	0	0	0	8	0	0	0	2:00	0	0	0	1	0	2	29	M-NA
R-005	G	1	0	1	1	4	0	1	0	0	0	1	0	0	3	0	0	0	2:00	0	0	0	0	6	0	1	M-A
R-006	G	1	0	3	1	0	0	0	0	6	2	2	0	0	7	0	0	0	2:00	0	1	0	1	4	1	29	M-A
R-007	G	0	0	0	0	0	0	0	1	1	0	3	0	0	8	0	0	0	1:00	0	0	0	0	1	0	29	M-A
R-008	G	1	0	0	1	3	0	1	0	0	1	5	0	0	5	0	0	0	2:00	0	0	1	1	0	3	1	S-NA
R-009	G	0	0	0	0	0	0	1	0	4	0	0	0	0	8	0	0	0	:30	0	0	0	0	3	0	29	S-NA
R-010	M	2	0	5	1	0	0	2	0	4	0	3	0	0	9	0	0	0	1:30	0	0	0	1	3	0	29	M-NA
R-011	M	0	0	0	0	0	0	1	0	0	0	4	0	0	4	0	1	0	1:30	0	0	0	0	3	1	29	M-A
R-012	M	1	0	1	2	2	0	1	1	4	2	12	0	0	13	0	4	0	2:00	0	1	0	4	4	3	1	S-A
R-013	M	0	0	0	0	0	0	0	0	0	0	2	1	0	6	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-014	M	1	0	3	1	0	0	1	0	5	0	3	0	0	9	0	1	0	1:30	0	0	0	0	2	0	29	S-A
R-015	M	1	0	1	0	0	0	1	0	0	3	2	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	2	1	8	0	0	7	0	0	0	1:30	0	0	0	0	0	3	1	M-A
R-017	W	0	0	0	0	0	0	0	0	1	3	2	0	0	6	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	1	2	1	0	0	5	0	0	0	2:00	0	0	0	0	0	1	29	M-A
R-019	M	0	0	0	0	0	0	0	0	2	0	2	1	0	4	0	0	0	:30	0	0	0	0	0	0	1	M-A
R-020	W	1	0	1	1	0	0	1	0	6	1	1	0	0	8	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	1	0	4	0	0	7	0	0	0	1:00	0	0	0	0	0	3	1	S-A
R-022	W	1	0	2	1	0	0	1	0	7	1	2	0	0	10	0	1	0	2:30	0	0	0	1	0	2	29	S-A
R-023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	2	0	1	2	1	0	2	0	1	3	3	0	2	5	0	0	0	1:30	0	0	0	0	0	0	1	S-A
R-025	G	0	0	0	0	0	0	0	0	2	0	1	0	0	7	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 27 TRACK WIDTH 3.5' LENGTH 10' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	0	1	0	0	1	0	0	3	3	0	0	3	0	0	0	1:30	0	0	0	0	0	0	11	M-NA
R-003	G	3	0	1	2	4	0	3	0	1	3	4	0	0	6	0	0	0	2:00	0	0	0	1	1	0	1	M-NA
R-004	G	1	0	0	1	0	0	1	0	2	2	0	0	0	4	0	0	0	:30	0	0	0	0	0	1	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	0	1	3	0	0	7	0	0	0	:30	0	0	0	4	3	3	1	M-A
R-006	G	0	0	0	0	0	0	0	0	3	2	0	0	0	6	0	0	0	1:30	0	0	0	1	1	2	29	M-A
R-007	G	0	0	0	0	0	0	0	0	5	3	0	0	0	5	0	0	0	2:00	0	0	0	2	1	2	29	M-A
R-008	G	0	0	0	0	0	0	0	0	2	4	2	1	0	7	0	0	0	1:00	1	0	0	2	1	0	1	S-NA
R-009	G	1	0	1	1	0	0	0	0	0	2	0	0	0	4	0	0	0	2:00	1	0	0	0	1	0	29	S-NA
R-010	M	1	0	2	2	2	0	1	1	3	4	3	0	0	7	0	0	0	1:30	0	0	0	0	0	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	4	2	3	0	0	15	0	2	0	1:00	0	0	0	0	0	0	29	M-A
R-012	M	4	0	3	7	3	0	4	0	1	2	3	1	0	6	0	0	0	2:30	0	0	0	0	0	0	1	S-A
R-013	M	2	0	1	4	4	0	2	0	3	1	1	0	0	5	0	0	0	2:00	0	0	0	0	0	1	1	S-A
R-014	M	0	0	0	0	0	0	0	0	1	2	3	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-015	M	2	0	0	2	2	0	2	4	0	2	7	1	0	13	0	1	0	1:00	0	0	0	0	0	0	1	S-NA
R-016	B	0	0	0	0	0	0	0	0	1	2	0	0	0	5	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-017	W	0	0	0	0	0	0	0	0	4	1	1	0	0	10	0	0	0	1:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	9	3	3	0	0	20	0	1	0	1:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	1	0	1	0	0	5	0	0	0	1:00	0	0	0	0	0	1	1	M-A
R-020	W	0	0	0	1	0	0	0	0	3	2	0	0	0	5	0	0	0	1:00	0	0	0	3	0	0	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	1	1	1	0	0	5	0	0	0	1:00	0	0	0	0	0	0	1	S-A
R-022	W	1	0	1	1	0	0	1	1	1	2	0	0	0	5	0	0	0	1:00	0	0	0	0	0	0	29	S-A
R-023	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	1	0	0	1	0	0	1	1	0	2	2	0	0	11	0	0	0	1:30	0	0	0	0	0	1	1	S-A
R-025	G	0	0	0	0	0	0	1	0	2	0	1	0	0	6	0	0	0	1:00	0	0	0	0	0	0	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 28 TRACK WIDTH 28' LENGTH 3.5' RADIUS 5'

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-NA
R-002	G	7	0	9	1	2	0	7	0	2	2	4	0	0	18	0	1	0	4:00	2	0	1	0	3	0	11	M-NA
R-003	G	3	1	3	2	1	0	3	0	2	4	3	0	0	10	0	1	0	4:30	1	2	0	3	3	2	1	M-NA
R-004	G	5	1	3	3	7	0	6	0	6	1	5	0	0	13	0	1	0	6:00	2	3	3	3	0	2	29	M-NA
R-005	G	1	0	3	1	0	0	1	0	7	2	3	0	0	13	0	3	0	4:00	1	2	1	4	3	3	1	M-A
R-006	G	2	0	4	2	4	0	2	0	3	0	5	0	0	10	0	1	0	3:30	0	0	0	1	5	1	29	M-A
R-007	G	2	0	2	2	2	0	2	1	2	1	5	0	0	12	0	1	0	3:30	0	0	1	2	5	1	29	M-A
R-008	G	1	0	4	1	0	0	1	0	4	1	1	0	0	12	0	1	0	2:30	0	0	0	5	2	7	1	S-NA
R-009	G	3	0	0	3	3	0	3	1	4	1	0	0	0	6	0	0	0	3:30	1	0	2	6	3	3	29	S-NA
R-010	M	6	2	3	5	8	0	4	0	3	1	4	1	0	11	0	1	0	6:30	0	1	0	1	5	0	29	M-NA
R-011	M	4	1	0	3	6	0	4	0	10	4	10	2	0	20	0	5	0	5:30	0	0	0	2	2	0	29	M-A
R-012	M	2	0	6	4	0	0	2	0	5	1	1	0	0	10	0	1	0	2:30	0	0	0	0	2	2	1	S-A
R-013	M	5	1	2	6	4	0	4	0	4	2	6	0	0	15	0	2	0	4:00	0	0	0	0	4	0	1	S-A
R-014	M	1	0	1	2	1	0	1	0	5	3	3	1	0	13	0	0	0	2:00	0	0	0	0	0	0	29	S-A
R-015	M	3	0	2	1	0	0	3	0	1	3	1	0	0	7	0	0	0	2:00	0	0	0	0	0	1	1	S-NA
R-016	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-A
R-017	W	0	0	0	0	0	0	0	0	3	4	1	0	0	15	0	0	0	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	0	0	3	0	0	6	0	0	0	2:00	0	0	0	0	0	3	29	M-A
R-019	M	0	0	0	0	0	0	0	1	1	1	1	2	0	15	0	3	0	1:30	0	0	0	2	0	3	1	M-A
R-020	W	0	0	2	5	3	0	1	1	3	2	8	0	0	12	0	1	0	3:00	0	0	0	1	0	0	29	M-NA
R-021	W	1	0	1	1	0	0	0	0	5	1	5	0	0	13	0	1	0	2:00	0	0	0	1	1	0	1	S-A
R-022	W	9	2	10	9	14	0	7	0	8	2	5	2	0	14	0	3	0	10:00	0	0	0	1	0	4	29	S-A
R-023	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	1	0	1	1	0	0	1	0	2	4	2	0	0	6	0	0	0	2:30	0	0	0	1	0	0	1	S-A
R-025	G	7	1	7	10	11	0	6	0	10	2	6	1	0	18	0	8	0	9:30	0	0	0	4	0	5	29	S-A

VEHICLE CONTROL TEST DATA SHEET

TEST PHASE: Roadway ZONE NO. 29 TRACK WIDTH 3.5' LENGTH 27' RADIUS ---

Test No.	Oper.	Camera Pan						Steering						Motion					Time	Major Fail			Minor Fail			Starting Zone	Camera Config.
		Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Ent	Full Left	Step Left	Cnt	Step RT	Full RT	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		F	C	R	F	C	R		
R-001	G	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	--	-	-	-	-	-	-	1	M-NA
R-002	G	1	0	0	1	0	0	1	0	4	3	0	0	0	11	0	0	0	1:30	0	0	0	0	0	0	11	M-NA
R-003	G	1	0	0	1	0	0	1	0	1	3	2	0	1	14	1	0	0	2:30	0	0	0	1	0	1	1	M-NA
R-004	G	2	0	1	0	2	0	1	0	1	1	1	0	0	13	0	0	0	2:00	0	0	0	0	0	2	29	M-NA
R-005	G	0	0	0	0	0	0	0	0	3	3	1	0	2	11	2	0	0	2:30	0	0	0	1	1	1	1	M-A
R-006	G	0	0	0	0	0	0	0	0	0	1	3	0	3	5	3	0	0	2:00	0	0	0	0	0	0	29	M-A
R-007	G	0	0	0	0	0	0	0	0	2	4	3	0	0	12	0	0	0	2:30	0	0	0	0	0	0	29	M-A
R-008	G	0	0	0	0	0	0	0	0	2	4	2	0	0	14	0	0	0	1:30	0	0	1	1	1	2	1	S-NA
R-009	G	0	0	0	0	0	0	0	0	2	3	5	0	0	15	0	0	0	1:30	0	0	0	1	0	0	29	S-NA
R-010	M	2	0	1	2	1	0	1	0	2	5	5	0	0	12	0	0	0	2:30	0	0	0	1	1	0	29	M-NA
R-011	M	0	0	0	0	0	0	0	0	3	6	3	0	0	13	0	0	0	2:30	0	0	1	0	0	1	29	M-A
R-012	M	2	0	0	1	1	0	1	0	3	7	5	0	0	14	0	0	0	1:30	0	0	0	2	3	3	1	S-A
R-013	M	0	0	0	0	0	0	0	0	2	4	2	0	0	13	0	0	0	1:30	0	0	0	0	0	2	1	S-A
R-014	M	1	0	1	1	0	0	1	0	2	4	3	0	0	14	0	1	0	3:00	0	0	0	0	0	0	29	S-A
R-015	M	3	0	1	2	2	0	2	0	1	2	1	0	0	9	0	1	0	2:30	0	0	0	2	0	1	1	S-NA
R-016	B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	M-A
R-017	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2:00	0	0	0	0	0	0	1	M-A
R-018	W	0	0	0	0	0	0	0	0	2	2	3	0	0	14	0	0	0	2:00	0	0	0	0	0	0	29	M-A
R-019	M	0	0	0	0	0	0	0	0	3	5	2	0	0	14	0	0	0	1:30	0	0	0	0	0	0	1	M-A
R-020	W	0	0	0	2	1	0	0	0	1	4	3	0	0	14	0	0	0	3:00	0	0	0	0	0	1	29	M-NA
R-021	W	0	0	0	0	0	0	0	0	2	4	2	0	0	15	0	0	0	1:00	0	0	0	1	0	1	1	S-A
R-022	W	1	0	1	2	1	0	1	0	0	1	1	0	0	12	0	0	0	2:30	0	0	0	0	0	0	29	S-A
R-023	W	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	S-NA
R-024	G	0	0	0	0	0	0	0	0	1	4	3	0	0	9	0	0	0	?	0	0	0	0	0	0	1	S-A
R-025	G	0	0	1	1	1	0	1	0	2	3	3	0	0	12	0	0	0	2:30	0	0	0	0	0	1	29	S-A

TANK TRAP TEST DATA

TANK TRAP TEST COMMAND-TIME HISTORY

Test No	Oper	Camera Pan						Steering						Motion					Time
		Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev	
T-001	G	22	1	24	11	32	0	19	0	8	9	11	0	0	22	0	0	0	14 min
T-002	G	25	0	30	18	25	0	20	0	14	9	13	0	0	23	0	0	0	16 min
T-003	G	25	1	32	18	35	0	27	1	15	12	19	0	0	31	0	6	0	20 min
T-004	G	36	0	43	16	43	0	32	1	18	16	13	0	0	30	0	10	0	29 min
T-005	G	27	0	42	14	36	0	24	0	12	13	11	0	0	26	0	3	0	16 min
T-006	G	27	2	35	13	43	0	27	0	10	15	20	0	0	28	1	6	0	16 min
T-007	M	37	1	55	38	25	0	34	8	22	39	21	6	1	91	17	34	3	40 min
T-008	W	9	0	20	12	9	0	6	0	4	8	3	2	2	37	7	5	0	16 min
T-009	W	11	0	17	22	16	0	12	0	3	12	11	0	0	35	7	0	0	15 min
T-010	W	22	2	20	17	31	0	13	4	12	11	13	0	1	39	5	15	0	25 min
T-011	W	17	0	32	23	33	0	19	0	15	17	14	0	0	29	2	4	0	22 min
T-012	W	25	3	26	21	35	0	24	1	9	23	25	4	0	42	8	20	1	32 min
T-013	W	19	0	20	14	13	0	16	2	13	15	10	2	0	31	6	0	0	17 min
T-014	M	18	0	25	15	29	0	14	6	8	25	7	6	2	57	21	22	0	25 min
T-015	M	15	0	15	18	32	0	13	4	10	16	7	2	0	21	22	7	0	17 min
T-016	M	14	1	34	18	27	0	13	4	13	16	10	0	2	45	10	10	0	22 min
T-017	M	11	0	18	13	20	0	9	4	7	10	8	3	1	40	7	9	0	12 min
T-018	M	15	0	14	12	6	0	12	1	14	10	5	1	1	28	7	7	0	9 min
Total		375	11	502	313	490	0	334	36	206	276	221	26	10	661	120	158	4	363 min

TANK TRAP TEST COMMAND-TIME HISTORY AFTER ENTRY INTO FIELD

Test No	Oper	Camera Pan						Steering						Motion					Time
		Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev	
T-001		Not Available																	
T-002		Not Available																	
T-003		Not Available																	
T-004	G	10	0	11	3	20	0	12	0	10	7	9	0	0	10	0	9	0	13 min
T-005		Not Available																	
T-006		Not Available																	
T-007	M	7	0	13	4	1	0	7	1	5	7	2	2	0	15	1	7	0	9 min
T-008		Not Available																	
T-009	W	2	0	7	4	2	0	2	0	3	3	1	0	0	8	0	0	0	4 min
T-010	W	1	0	4	1	3	0	1	1	0	0	0	0	0	1	0	0	0	2 min
T-011	W	1	0	6	2	4	0	3	0	2	1	0	0	0	1	0	0	0	2 min
T-012	W	2	0	6	1	7	0	2	0	0	2	2	0	0	4	0	0	0	6 min
T-013	W	4	0	6	2	6	0	4	0	0	3	4	0	0	2	0	0	0	4 min
T-014	M	10	0	13	8	21	0	9	6	7	17	5	4	1	37	15	20	0	19 min
T-015	M	2	0	5	3	8	0	2	0	3	3	1	0	0	10	2	1	0	4 min
T-016	M	4	0	10	4	9	0	4	4	5	9	3	0	0	21	2	9	0	10 min
T-017	M	4	0	7	3	4	0	3	3	2	4	0	2	1	14	1	6	0	5 min
T-018	M	4	0	6	3	1	0	4	1	5	5	2	0	0	9	2	5	1	4 min

GENERAL LUNARIUM TEST DATA

GENERAL LUNARIUM TEST COMMAND-TIME DATA

Test No	Oper	Camera Pan						Steering						Motion					Time Min	Course #
		Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Ent	Full Left	Step Left	Cnt	Step Rt	Full Rt	Cont Fwd	Step Fwd	Stop	Step Rev	Cont Rev		
L-001	G	95	5	99	84	126	0	95	0	24	41	47	1	59	81	65	10	0	117	1
L-002	G	58	1	58	51	71	0	55	0	23	28	34	1	19	76	20	9	0	71	2
L-003	G	104	4	105	66	105	1	100	2	33	50	56	2	26	127	28	19	0	94	3
L-004	G	24	0	12	14	13	0	25	0	17	31	38	1	33	84	34	6	1	35	4
L-005	M	20	0	14	15	13	0	21	3	15	26	22	3	31	57	36	1	0	29	4
L-006	W	16	0	3	10	12	0	17	1	15	32	28	3	24	81	27	8	0	31	4
L-007	M	70	4	31	48	54	0	48	6	37	59	45	8	26	104	33	33	2	68	3
L-008	W	46	2	52	41	43	0	41	4	28	51	39	5	21	135	24	25	0	66	3
L-009	M	35	0	27	31	20	0	28	1	18	24	19	3	33	60	37	6	0	37	1
L-010	W	36	3	15	16	32	0	35	3	12	36	30	0	21	77	28	27	7	35	1
L-011	M	24	0	28	25	29	0	22	3	20	25	15	6	17	68	25	13	0	32	2
L-012	W	25	0	23	24	20	0	22	3	14	24	19	4	11	94	15	6	0	33	2